THE

JOURNAL

OF THE

Franklin Institute,

DEVOTED TO

Science and the Mechanic Arts.

EDITED BY

PROF. HENRY MORTON, PH.D.,

ASSISTED BY THE COMMITTEE ON PUBLICATIONS.

THIRD SERIES.

VOL. LVI.

WHOLE NO. VOL. LXXXVI.

July—December, 1868.

PHILADELPHIA:
PUBLISHED BY THE FRANKLIN INSTITUTE AT THEIR HALL.
1868.

JOURNAL

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FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] JULY, 1868. [No. 1.

EDITORIAL.

ITEMS AND NOVELTIES.

The Hoosac Tunnel.—We have just received the yearly report of the Managing Committee, Engineers, and others concerned in this great work, and find in it many matters of lively interest. In a brief notice of the previous year's report, which we made in this *Journal*, Vol. LIV., p. 9, we related the unfortunate experience which had been encountered in the use of machine drills, and quoted the results obtained, which spoke strongly in favor of the hand application of the tool, both as regards speed and cost. From this, and an article by Prof. De Volson Wood, published in the same volume, p. 83, may be gathered the conclusion reached by the Resident and Consulting Engineers, from a long and thorough trial, namely, that for some reason, rock drilling by machinery, applied with such wonderful success on the Alps, in the Mt. Cenis Tunnel, was with similar machinery a failure on the Hoosac Mountain and Tunnel. This conclusion, though seemingly *demonstrated*

by facts, appeared so extraordinary, that these gentlemen, even while expressing it, could not rest satisfied with such a result, but advised that while in obedience to the commands of experience, the ruinous experiment with machines in the tunnel must be discontinued and hand labor resumed; yet that outside and on an economical scale, efforts should be maintained to improve and strengthen the machinery, so as, if possible, to create something fitted for the work.

Success in this direction was, however, nearer than they had imagined, for, as appears from Prof. Wood's article above mentioned, the adverse report could hardly have been fairly in circulation before improvements were effected in the machines, which completely turned the tables of comparison over to the other side. This timing of the improvement was most unfortunate, as regards the reasoning and advice of the report, which were perfectly sound on the basis of the facts then existing, but of course could have no relation to an absolutely inverted order of things and conditions.

Such an accident or malicious perversity of events, with a young engineer, whose reputation was in the future, might have been serious (thanks to the general tendency to consider that all which goes right is by chance, and all that goes awry is "somebody's fault,") but with Mr. Latrobe, it is simply a good joke, which no doubt his friends have not failed to enjoy. With the improved machines, however, the work has progressed famously, and in face of a progress at the East Heading during the previous year of about 590 feet, has to show 1277 feet of actual advance, notwithstanding a heavy drawback from unusual deficiencies in the supply of water power, by which the compressed air was furnished to the machines.

In connection with this improvement in the drilling machines, we will quote a remark of much importance, when its relations are understood, which occurs in Mr. Latrobe's report, p. 31. After describing the improvement in the Burleigh drill, he remarks:

"While saying this, however, I do not feel prepared to pronounce it the *ne plus ultra* of a machine drill, nor to give up the expectation that one with fewer parts and of more compact and simpler structure will, in due time, be designed and made to yield even better results at reduced cost. There is now lying in the shop, at the east end, a machine invented by parties from Michigan, differing in several respects from the Burleigh drill, although claimed, as I am told, to conflict with patent rights in the latter. Of this part of the case

I know nothing as yet, but the machine has been reported to me as working with great efficiency and small cost of repairs, on account of its fewer parts and simpler construction. It seems to have been introduced into the tunnel by the late contractors, and to have been disused on their retirement from the work; but from what reason, I am unable to state, as its performance is said to have been exceedingly promising of improvements over previous machines."

From this remark, it will be seen that Mr. Latrobe belongs to that large, but we are happy to say daily decreasing class of engineers, who do not read the *Journal of the Franklin Institute*, otherwise he would have known that the machine in question was invented by Professors Wood and Robinson, and exhibited many important features of novelty and improvement.

The cause of its disuse we believe (though this is unauthentic and simply on the ground of a general impression), was a little of the "dog in manger" policy, on the part of those controlling the other machine.

It appears from these reports, that during a large part of the past year, the work at the tunnel was under the personal supervision of one of the State Commissioners, Hon. Alvah Crocker, who pushed forward the work with great energy and marked success. During three months, part of the work was prosecuted under contract by Messrs. Dull, Gowan, and White, who were the contractors for the Chicago Lake Tunnel.

There appears to exist a difference of opinion between the Commissioner Superintendent, Mr. Crocker, and the Consulting Engineer, Mr. Latrobe, on several important subjects.

Thus the former advocates the prosecution of the work by the State for some time longer, before any resource is had to working by contract, in order that the very expensive preliminary works already constructed may be utilized, and made in this sense, remunerative to the State. He also calls attention to the fact, that the rate of progress under contract with Messrs. Dull & Co., was decidedly less than under his own supervision acting for the State.

Mr. Latrobe on the other hand, adheres to his previous opinion as to the advantage of the contract system, and shows that the cost of the work executed under contract was in a marked degree less than that carried on by day labor for the State.

Again, with reference to the pumping machinery for the main shaft and west shafts. Mr. Crocker has used so far with success, and advo-

cates for the future, cheap, compact and light, fast running pumps, such as those of Knowles & Sibley, placed at the bottom of the shaft with their boilers and furnaces, which thus assist in the ventilation. Mr. Latrobe, on the contrary, advises the erection of large Cornish pumps at the mouth of the shaft, even at a very heavy outlay. The relative merits of these plans will depend much in the present case, upon the length of time for which the pumping process will be continued.

With reference to the use of Nitro-Glycerine, Mr. Crocker speaks sanguinely, and describes arrangements which he has made to give it a thorough trial, and to manufacture the article on the ground. Want of space precludes our saying more on this subject at present, but in our next issue we will return to it, and give in full the report of Mr. G. W. Mowbray, who has undertaken the manufacture of this powerful explosive.

In this connection, we would also refer to the article on Nitro-Glycerine, in the present number p. 40.

Continuous Profile Paper, by James W. Queen & Co. Every engineer who has had any experience in that direction, is feelingly aware of the annoyance and difficulty attending the use of sheets of profile paper which have been attached to each other by pasting, for the purpose of producing such a continuous roll as is required in survey of long railroad lines. It would be useless for us to enumerate the difficulties resulting from uneven surface, want of fit, &c., which are thoroughly realized by all. The great value of an article such as the continuous profile paper, a minute fragment of which is appended as a specimen herewith, which is 22 inches from top to bottom, and of any length that is desired, and last but not least, costs but 30 cents a yard, will therefore at once be realized. Nor is the use of this article confined to the engineer. The student and experimenter in nearly every branch of science, continually requires some similar means for projecting and comparing results and observations, in one or other of the methods so ably discussed by Prof. Mayer in his "Lecture Notes," which have appeared from time to time in this *Journal.*

The subjoined letter gives the opinion of skillful engineers of long standing, in regard to the merit of the Continuous Profile Paper:

PHILADELPHIA, *Jan.* 31. 1868.

MESSRS. JAMES W. QUEEN & CO.

Gents:—We have examined your Continuous Profile and Cross

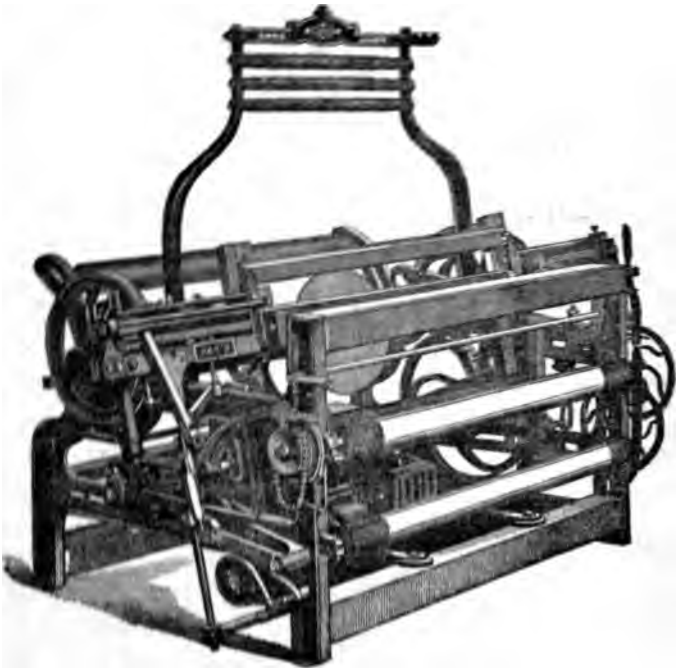
Section Paper, and have no hesitation in pronouncing it a great improvement over the sheet plan in which such papers have been heretofore printed. The want of this kind of profile paper has been much felt for years past, particularly on surveys of long railroad lines, for, in joining the ends of different sheets, we have found it extremely difficult to do it, or have it done with accuracy, on account of the unequal shrinking of the paper in printing and drying; for this reason only, your Continuous Paper will supersede the Sheet Profile Paper; but, in addition, we notice the price of your Continuous Profile Paper is less than we have always paid for the same article in sheets. This, we consider, adds very much to the merit of your invention.

STRICKLAND KNEASS, *Civil Engineer.*
JOHN C. TRAUTWINE, *Civil Engineer.*
W. H. WILSON, *Ch. Eng. Penn'a R. R.*

Power Looms.—As Lowell, Fall River, Lawrence and Manchester, in the Eastern States, are noted for the manufacture of plain cottons, such as print cloths, so is Philadelphia famous for its cotton checks, ginghams, plaid flannels, balmoral skirts, and such cloths, in which filling of more than one color is used. Thirty-five years ago, all checks, ginghams and plaids of all descriptions were the production of the hand loom. It was about 1833, that the first double box power loom was started in this country by the late J. C. Kempton, at the Schuylkill Factory, at Manayunk (now Twenty-first Ward of this city). Mr. Kempton was the first manufacturer who attempted the production of plaids on the power loom. His experiments were attended with great success, but met with great opposition from the hand loom weavers, and threats and attempts were made to burn the factories of Mr. Kempton in 1837. Other manufacturers, seeing the success of Mr. Kempton, and the great profits attending the manufacture of plaids on the power loom, had many of their single box looms altered, and others made to weave from two to four colors of filling, and at the present day, thousands of double box power looms are running in Philadelphia and vicinity, and not ten hand looms are now to be found making checks or ginghams. One firm at Manayunk has about 500 to 600 double box power looms on checks and ginghams, producing from fourteen to fifteen thousand yards daily.

Since the first double box power loom was started at Manayunk by Mr. Kempton, many improvements have been made in power

looms for weaving plaids. The following illustration shows a power loom for weaving with two colors of filling, called a two box loom, the manufacture of Mr. Thomas Wood, of this city, at his loom



works, Twenty-first and Hamilton streets. Mr. Wood was one of the first of our mechanics to engage in the building of double box power looms, and has made them a specialty, and with about twenty years practice and experience, he has in that time added many improvements. The above cut represents one of his looms, in which the box motion is of the star pattern, and for operating two shuttles or two colors of filling. This form of box motion is considered very simple, durable, and capable of being run at a great speed, as high as 140 picks per minute. One of the improvements introduced by Mr. Wood, is the casting of the shuttle box in one piece, no bolts or rivets being used, as was formerly done in those made of brass, wrought or malleable iron. There is less liability to get out of order, and a capacity of running at a great speed. In this loom, the filling stop motion is connected with the pawl that operates the pattern chain of the box motion, which acts on the pawl instantly

by raising it, and preventing it from changing the pattern when the filling is broken or exhausted in one of the colors, thereby saving filling or yarn, and time.

The stop for the shuttle is independent of the box, and is worked by the motion of the lay. It has been much improved of late by adding a spiral spring to the under part of the stopper, to receive the force of the shuttle as it enters the box, which effects a great saving of pickers and shuttles, and is not so liable to break the filling, or jar off the bobbin or copp.

Mr. Wood is applying other improvements to his looms, for which he now has patents pending before the patent office. See his advertisement in the columns of this *Journal.*

Philadelphia and New Hope Railroad.—The route of a proposed railroad from Philadelphia to New Hope is being surveyed, and the engineers announce that easy grades can be found over a large portion of it, leading through an extremely rich and fertile country.

A "red line" car containing through-freight started a few days ago from Boston to Cheyenne, 2050 miles. The freight will go through without breaking bulk.

Progress and Effect of R.R. Consolidation.—In the infancy of what has grown to be a vast and complicated system, intimately interwoven with all the interests of the State, it was natural and proper that short roads for local business should be built. Through-lines only existed in the imagination of some men ahead of their time. As other roads were needed they were constructed. Rival routes were laid out. The grain from the West, the cotton from the South, called for cheap, quick transportation to the seaboard, to be exchanged for groceries and manufactured goods. There was no resource but to condense, centralize, consolidate. With larger capital, influenced less by local interest and managed with vastly more energy, the consolidations could and did offer greater facilities for business, and traffic took advantage of these facilities.

From New York *via* Philadelphia and Pittsburg, to Cheyenne, at the base of the Rocky Mountains, a distance of 1917 miles, but three changes of cars are made, and five companies control the whole distance. Between New York and New Orleans, 1500 miles, there are ten different roads, while between New York and Charleston, only 788 miles, there are also ten.

If the prices in the stock markets can be considered a test of value,

stockholders certainly should favor consolidation. Take up the stock list and compare the prices of the stock of those companies formed by agglutination—by link added to link—a new line made here, a branch extended there with that of those formed complete, whose termini are hundreds of miles apart, and between which there is a wilderness.

In England, where they are much in advance of this country in matters pertaining to railroad science (with the exception, perhaps, of bell-ropes), the tendency and practice has been to consolidate, and it has been carried to the extreme, and yet none of the evils which are often predicted here have resulted there. In 1844 a bill passed Parliament, providing that all roads chartered thereafter could be purchased by the Government after twenty-one years. This bill covers over five-sixths of the roads in the kingdom. The propriety and practicability of such purpose is now being discussed. The measure was proposed and carried through by Mr. Gladstone, and it is not improbable that he may take it in hand again. The consolidations or amalgamations, as they are called there, of the thirteen great lines, are almost numberless.

The London and North-western, the greatest company of the kingdom, with 1307 miles of road, is composed of twenty-eight companies: the business per mile carried on some of which, as the Liverpool and Manchester, and London and Birmingham, surpasses anything our roads can show. The North-eastern is composed of fourteen, the North British of eleven, the Manchester, Sheffield, and Lincolnshire of thirteen companies.

In France the State must do everything. A wise legislation has now, however, freed the Treasury from any ownership in any of the roads, and a very general supervision is all that it retains. There have been projected and partly aided by the State six great lines, now entirely owned by corporations.

First.—The Northern line from Paris to Calais, Boulogne, Dunkirk, and the Belgian frontier.

Second.—The Western line from Paris to Havre and Dieppe.

Third.—The Orleans or Central line, from Paris to Orleans, Bordeaux, Nantes, &c.

Fourth.—The Southern line, from Bordeaux to Cette Bayonne, Toulouse, &c.

Fifth.—The Paris, Lyons, and Mediterranean line from Paris to Marseilles, with branches to Cette Bayonne, &c.

Sixth.—The Eastern line from Paris to Strasburg, Chalons-sur-marne, &c.

A glance at the map will show that these lines were laid out not only with a view to the demands of traffic in times of peace, but as offensive and defensive lines in times of war.

In ninety-nine years from 1852, the roads are to revert to the State, suitable provision by means of a sinking fund or an equivalent being made for the stockholders. A similar law obtains in Prussia, the Government agreeing to pay the stockholders an amount equal to twenty-five times the average dividend for the preceding five years. In Belgium the State owns all the roads, and in lowness of fare, economy of working, and excellence of arrangements, they equal all and surpass most of the European roads.

We append a table, showing the cost, length (excluding branches leased), and cost per mile, of some of the longest American and English roads.

Railroads.	Cost.	Length, including branches owned.	Cost per Mile.
Erie	$48,507,541	459	$105,680
New York Central	34,133,911	550	61,500
Pennsylvania	21,135,439	387	54,660
Atlantic & Great West	56,357,560	387	145,630
Chic. & North-west	43,234,929	800	51,040
Mobile & Ohio	17,922,359	469	38,250
Illinois Central	41,478,280	708	58,590
Pitts. Ft. W. & Chic	23,841,274	529	45,070
	$286,611,293	4,294	$66,747
Caledonian	£21,200,283	573	£36,967
Great Eastern	28,123.000	709	39,426
Great Northern	20.519.560	487	44,709
Great Western	49,246,137	1,311	37,564
Lancaster & Gerk're	22,475,855	403	55,771
London & N. Western	56,180,613	1,307	42,308
London & S. Western	16,460,557	503	32,725
Midland	30,679,036	761	40.743
North-eastern	39,023,507	1,229	31,752
South-eastern	19,891,311	330	60,277
North British	18,799,778	752	25,133
Manch., Sheff. & Lon	15,336,341	246	62,343
	£387,935,978	8,611	£39,245

or in dollars at five to the pound sterling, we have 8611 miles of railway, costing $1,689,679,890, gold, or $196,225 per mile. Some of the shorter roads cost much more than this. The North Lon-

don, eleven miles in length, cost the enormous sum of $1,352,935, gold, per mile. The London, Chatham, and Dover, cost for its one hundred and thirty-six miles $704,020, gold, per mile. The nearest approach to these enormous sums in this country is in the construction of the connecting railroad through Philadelphia, uniting the New Jersey roads with the Pennsylvania Central, and Philadelphia, Wilmington and Baltimore roads. In the report of the consolidated companies, the President estimates the cost of constructing these seven miles at $2,000,000—nearly $300,000 per mile.

The Spectroscope and the Bessemer Process.—Almost with the first announcement of the action and indications of the spectroscope, it was proposed to apply it in the manufacture of iron as an indicator of the progress in change or conversion of the material. See this *Journal*, Vol. XLV. p. 128. After many and various experiments, which we have from time to time noticed, it is now at last announced that a satisfactory result has been reached by Prof. Lielegg and Dr. Roscoe, and that in the Bessemer process, the proper moment for stopping off the blast and introducing the spiegeleisen can be determined by observation of the flame escaping from the converter, with a spectroscope. The order of changes in the spectrum are from first to last as follows: When the charge is started, a luminous spectrum appears, due to the volley of sparks, with no lines; soon after the sodium line is seen, followed by those of iron, lithium, potassium, hydrogen, nitrogen, and a number of bright lines with very dark spaces between, due perhaps to carbonic oxide and perhaps to carbon vapor, which occur principally in the green, these again disappear in inverse order to that of their development, and their total or partial extinction is the signal for the stoppage of the blast, and introduction of spiegeleisen.

The Town of Belfast, Maine, alive to the importance of having a direct connection with the Main Central Railway, has voted $600,000 to build a connection.

Improved Air-Pump.—By E. S. Ritchie, Esq., of Boston, Mass. A good air-pump, which will produce with certainty a vacuum approaching the Torricellian, is becoming almost a necessity, and certainly a most desirable possession to every physicist who is called upon to demonstrate to his classes the new developments of electrical science. In view of this fact, we are glad to receive and publish the following account of an air-pump, containing many new features,

devised and constructed by Mr. E. S. Ritchie, who is already so well known for the great improvements which he has introduced in the Induction Coil, Holtz Machine, and other Philosophical instruments, as well as by his Liquid Compass, and other valuable devices.

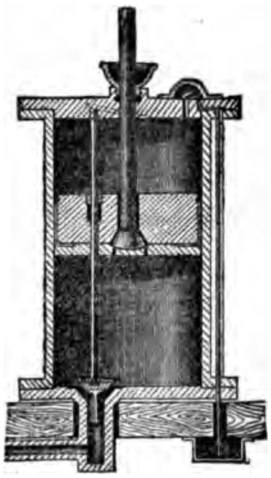
This new pump, with automatic valves above mentioned, may be described as follows:

The cylinder is made in the usual form. The motion may be given to the piston-rod by crank or lever. The peculiarities are in the construction of the piston and valves, and also in the manner in which motion is given to the valves.

Fig. 1 is a section showing the valves, &c., much exaggerated for distinctness.

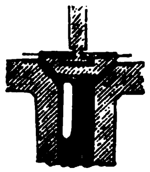
The lower valve is conical, held in place by a triangular stem fitting the tube; it is raised by the *valve-rod* passing up through a stuffing-box in the piston; an enlarged section (Fig. 2), shows the manner in which the attachment is made, which allows a motion of the rod sidewise, so that any slight change of form of the packing of the piston, or stuffing of the rod, cannot prevent the valve from shutting properly. The cone of the valve is ground to a perfect fit to its seat, but the valve is also furnished with a disk of oiled silk, which projects just beyond its outer edge, and touches the flat surface of the valve-seat; the valve-rod extends up, and its upper end is secured in a hole drilled in the upper plate, of depth to allow motion vertically to open the valve.

Fig. 1.



The *piston* is of thick brass, made in two parts, the upper piece has a hole drilled larger than the piston-rod; the lower part of conical form, ground to fit a cone on the piston-rod; this forms the piston-valve. The lower piece of the piston covers the end of the piston-rod, but allows it enough motion to open the valve; a series of small holes through the plate gives a free passage for the air to the valve.

Fig. 2.



A third valve is placed outside the cylinder, made of oiled silk in the usual way.

In the thickness of the upper plate of the cylinder is inserted a

steel lever, one end of which covers the valve-rod; the other end, when the lower valve is closed, is *flush* with the plate; but when the valve is raised it projects into the cylinder.

In action, the first motion upward of the piston-rod closes the piston-valve; the first motion of the piston opens the lower valve; as the piston ascends, the air above it is forced out through the upper valve; and air from the receiver flows unobstructedly into the cylinder. The piston strikes the tail of the lever, and at the instant of arriving at the top, closes the lower valve. The first downward motion of the piston-rod opens the piston-valve, the air remaining in the interstices above the piston distributes itself equally throughout the cylinder, but *none* can pass the lower valve back into the receiver. When the piston again reaches the bottom of the cylinder, the interstices below are filled with air as *rarefied* as a pump with ordinary valves can exhaust. The working parts are very substantial, not likely to be deranged, and are readily accessible.

Almost a Torricellian vacuum is obtained; a mercury gauge is brought within *one-fiftieth* of an inch. The Aurora Tube is filled with brilliant stratified light, in connection with the Induction Coil; water is frozen without acid, &c.

Transparent Sheet Gelatine.—On page 500 of the last volume, we published a short description of a new kind of magic lantern transparency, made upon the above substance, by Mr. Outerbridge, who has also prepared the gelatine in the following manner: A sheet of plate glass, of any desired size, is carefully cleaned and polished. There is then rubbed over its surface a very small quantity of oil (passing an almond over the plate answers excellently). The ordinary gelatine is dissolved in water and poured over the plate, which is then allowed to stand for about twenty-four hours. The gelatine has by this time hardened, and may be peeled off. It may be made insoluble in water, by mixing with it while fluid a small quantity of bichromate of potash. The most beautiful colors may be produced, and we have found the colored gelatine very useful for various purposes in the magic lantern. As for example, the disk, having seven different colors (Newton's recomposition of light), which being rapidly revolved, produces upon the screen a disk of white light. In the experiment of the reflection of light in a liquid vein, colored gelatine sheets may be used instead of stained glass, and are of course much cheaper and more easily put together.

New Railroad Bridge at Port Clinton.—The Port Clinton (Pa.) reporter of the *Reading Eagle* says: The Philadelphia and Reading Railroad Company have again commenced work on the new railroad bridge across the Schuylkill River at this place. It will probably be completed during the summer. It connects with the main road (to be constructed) from Port Clinton to Topton on the line of the East Pennsylvania Railroad.

The Missouri Pacific Railroad returns as gross receipts, for passenger and freight transportation, exclusive of Government transportation and tax, $2,536,445 for 1867.

The Brooks' Insulator in England.—Early last year it was announced that Monsieur Vicomte de Vougy, Director General of the Telegraph Lines of France, had appointed a commission of electricians to decide upon the style and material of an insulator for telegraph lines under his charge. This commission was composed of eminent electricians, among whom were Monsieurs Gaugain Gavorect, Du Moucel and others, whose names are familiar to all readers of works on electrical science. The most approved insulators of the different countries in Europe were procured and tested in the open air, exposed to the weather. Among others presented for trial was that of Mr. Brooks, mentioned in this *Journal*, Vol. LV., page 10, and also at page 149. After three months of trial, an order was given, on October 1, 1867, to Mr. Brooks for a sufficient number to enable the commission to make a practical test of their value. The result of this examination and test was made known through the columns of the *Semaine Financiere* of January 24, and *La Union* of February 4, stating that the Brooks had proved far superior to all its competitors. (This was reported in our March number for this year.)

The English Telegraphers hearing of the success of this Insulator, sent to Philadelphia for samples to test in comparison with their own in the fogs and mists of London.

A table of results, which has just been received, and is printed below, speaks for itself, and shows that the merits of this instrument are not lost by a change of climate or a transfer to hands in no wise interested in their development or exhibition.

We were present lately at a series of tests of the Brooks and other Insulators, made in this city, which fully confirmed the results obtained at Silverton, as shown in the following table. These we will give in full in our next issue.

TEST OF INSULATORS

MADE AT INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS CO., SILVERTOWN ESSEX, ENGLAND

CONSTANT OF GALVANOMETER, 1 DANIEL CELL, THROUGH 1,000,000 OHMADS	Date	March 1st, 1868	March 9th, 1868	March 20th, 1868	March 26th, 1868	March 31st, 1868
	Temperature	47° Fahr	40° Fahr	52° Fahr	46° Fahr	48° Fahr
	State of Weather	Very Dull	During and after rain	Atmosphere damp	During and after much fine rain	During a thick fog and frost
	Constant of Inst	816	800	885	866	837
	Numb. of Cells	500	100	500	500	500
DESCRIPTION OF INSULATORS	Number of Insulators tested	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator
United Kingdom Telegraph Co., large porcelain	4	8,500	830	20,000	10,000	40,000
Varley's Double Porcelain Cup	4	4,500	450	37,500	25,000	50,000
British and Irish Magnetic Co., porcelain	4	30,000	1,000	55,000	18,500	60,000
United Kingdom Telegraph Co., small porcelain	4	800	150	11,550	14,500	50,000
Brooks' Patent Insulator with 6 inch Pores Shank	6	2	0	2	1	6
Do. do. do.	6	8	0	11	0	4
Do. do. do.	6	7	0	6	0	1
Do. with lug for cross arm	1	200	80	104	90	8

Civil and Mechanical Engineering.

PNEUMATIC BRIDGE FOUNDATIONS.

By O. Chanute, C. E.

(Continued from page 391.)

The cylinder being thirty-five feet in diameter, it was out of the question to maintain, with the ordinary pneumatic machinery, the necessary pressure and volume of air for a sufficient number of workmen, operating at a depth of eighty-two feet, or under a pressure of two or three atmospheres. It was evident that the working space must be made as small as possible to ensure success. With this view, Mr. Brunel divided his cylinder in two parts; the bottom portion was provided with a spherical dome, under which the plenum was to be maintained, and the upper portion was so arranged that it could be removed after the masonry was built up. In the lower portion, there was under the dome an annular partition, concentric with the cylinder, divided into compartments, communicating with the exterior works by a pneumatic tube enclosed in another tube of greater diameter. This pneumatic tube was used in forcing air into the annular chamber, while the enclosing tube served to withdraw the materials excavated. As soon as the mud was removed from the annular space in this species of diving bell, masonry was built in its place, fitting accurately the rock bottom and iron sides, so as to shut out the water. This operation completed, it was contemplated to remove the inner dome and the pneumatic tube, and to work in the open air, in the centre of the masonry ring thus laid inside the cylinder.

In case of infiltrations, it was believed that ordinary pumps would suffice to keep the water down. Unfortunately, the space enclosed by the inner cylinder was found far from dry, the pumps moved by portable engines mounted upon the cylinder being unable to keep down the water, flowing in through crevices in the rock bottom. It became necessary to employ for this middle space the same process as for the annular chambers, and to resort to compressed air.

We believe that the founding of this pier occupied nearly three years, and that the health of the workmen suffered so seriously from the great air pressure which had to be maintained to counterbalance the water pressure (from two to three atmospheres), that

continental engineers are agreed that twenty-five metres (eighty-tv feet), is about the extreme limit to which it is advisable to carry t plenum process.

Russian Bridges.—In building the railway from Warsaw to S Petersburg, and its branches, very similar circumstances to thc which obtain in this country were encountered. The country w sparsely settled, foundries and machine shops few, and means transportation difficult. Rivers had to be crossed, resembling mu in their régime our western streams, while the variations of temp rature and ice freshets, were fully as severe as with us.

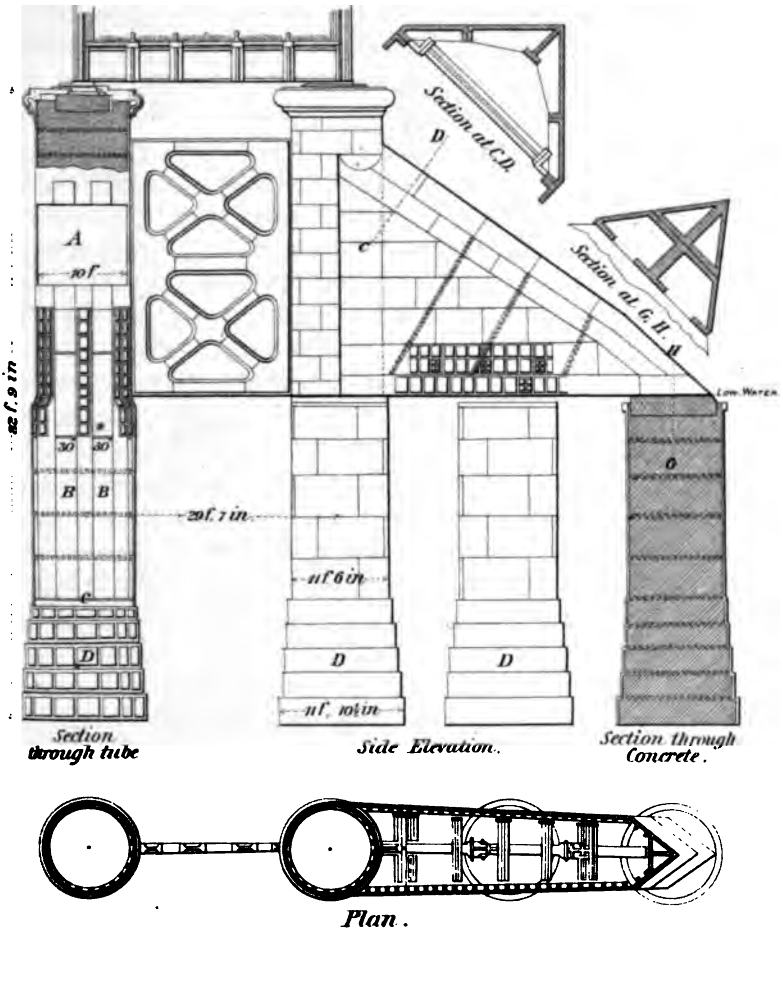
As no stone but a few scattered boulders was to be obtained, was decided to make large use of tubular iron piers and founc tions. The following is a list of some of the principal bridges that line.

Name of River.	Length of Bridge.	Number of Spans.	Number of Tubes in each Pier.	Diameter of Tubes.	Total weights of iron for Superstructure, Pier and Ice Breaker	
					Cast Tons.	Wrought Tons.
Dwina	874 ft.	3	4	14 ft. 9 in.	1768	3242
Niemen, at Kowno	985 "	4	4	11 ft. 6 in.	2100	1966
Bug	929 "	5	3	9 ft. 10 in.	1275	1642
Niemen, at Grodno	618 "	3	3	11 ft. 6 in.	1113	1324
Narew	559 "	3	2	9 ft. 10 in.	374	932
Vakka	274 "	3	2	6 ft. 6 in.	260	281
Vileika	250 "	3	2	6 ft. 6 in.	212	242

These bridges are all for double track, with wrought iron sup structure, and were built by contract by Mr. E. Gouin, of Fran from 1859 to 1862. The piers are all of cast iron tubes, protect by ice breakers, and filled with a concrete composed of Portla cement, 1 part; sand, 2 parts; broken stone, with a small quanti of brick, 3½ parts.

Plate III. gives an elevation and plan of those for the Kow bridge over the Niemen.

Kowno Bridge over the Niemen.



Lith. Jas. McGuigan Philada.

As all the iron work and castings were to be brought from France, Germany, and England, it was important that they should be of some form more easy of stowage and transportation than the ordinary full cylinder sections used in the pneumatic process; this could only be accomplished by multiplying the joints, while even with the usual form, considerable difficulty and loss is occasioned by the leakage of the compressed air between the flanges. To obviate these two opposite difficulties, and inspired by the success of the modified process employed at the Kehl bridge, which will hereafter be described, important changes were made in the arrangement of the tubes. The compressed air was confined to a working chamber, D, 15 feet high, of riveted wrought iron plates, at the bottom of the tube, closed at top by a diaphragm plate C, made in two halves for convenience in withdrawing, and connected with the air lock, A, by two service tubes of wrought iron, B B, 30 inches in diameter, and provided with internal ladders and hoisting gear. The volume of air to be supplied was thus reduced to the smallest possible quantity, leakages avoided, and great economy of both money and time secured. The diaphragm effectually protected the workmen from the fall of any stone, timber, or material from above, while it left the whole inside space above it available for ballast to sink the tube. Water was used for this purpose, being much cheaper and more easily handled than the rails or heavy cast iron weights generally employed elsewhere. The workmen went in and out, and the excavated materials were withdrawn through the service tubes, which were built in sections 4 feet 11 inches high. All the joints of the air lock and the working chamber with the diaphragm and service tubes were bolted together with rings of India rubber between the flanges.

As with this arrangement, leaks were no longer to be feared in the main tubes above the working chamber, their sections were cut up into four segments, provided with internal flanges, and securely bolted together.

As soon as the column was sunk to its intended depth, the working chamber was filled with concrete to a height sufficient to counterbalance the water pressure, the diaphragm, air lock and service tubes withdrawn for future use, and the remainder of the column filled with concrete in the open air.

Each pier of the Kowno bridge consists of four such columns, 11 feet 6 inches in diameter, sunk to a depth of 39 feet below low

water, through granitic sand. They rest upon a stratum of hard clay, and are embedded on an average about 33 feet in the sand. All parts exposed to shocks are 2¼ inches thick. The two up stream columns support an ice breaker of cast iron plates 2¼ inches thick, bolted together through internal flanges, and the other two columns support the trusses of the bridge.

The abutments consist of two columns of the same size, sunk to the same depth as the piers, the ice breakers being omitted.

It is stated that these columns, sunk in 1861, have stood ever since very well. The observed changes of temperature at the bridge site have been 135 degrees, or from —31° to + 104° Fahrenheit. The ice, which frequently attains a thickness of two or three feet, and gorges when breaking up, so that sometimes the water rises and falls five and six feet in an hour, has had no effect upon their stability.

It need scarcely be pointed out that in a country like ours, where timber is cheap and iron dear, the iron working chamber could in certain cases be surmounted with a tube made of wooden staves, which could be filled with concrete or cut stone masonry, either after the column was down to the desired depth, or (when great penetration and consequent weight was required), during the progress of sinking.

The same contractors in 1860–1, under the direction of General Kerbedz, a distinguished Russian engineer, put in similar tubes for the foundations of the masonry piers of the bridge across the Vistula, at Warsaw.

The piers are protected with ice breakers, inclined at an angle of 45 degrees, and are faced with granite, backed with red sand stone. The masonry rests upon four columns; two of these, 18 feet in diameter, are placed under the bearings of the trusses, 35 feet 6 inches between centres. The other two, 9 feet in diameter, are placed, the one between the two large columns, and the other under the ice breaker. A cast iron grillage resting upon the edges of the columns, spans over the intervening spaces and supports the masonry.

The tubes were built like those on the St. Petersburg and Warsaw Railway, with a working chamber of boiler plate, 13 feet high, surmounted by a cast iron shell, divided into 4 segments per section for the small columns, and 12 for the large ones. A wrought iron diaphragm, shaped like a truncated cone, formed the top of the

working chamber, and supported the water or soil which composed the ballast. The working tubes were connected with this dia phragm, and the excavated materials extracted through them.

The columns were sunk to a depth of 49 feet below low water, and a bed of concrete being laid for a few feet, solid masonry was filled in the tube above it. A coffer-dam built around the tubes, was then pumped out, the upper portion of the tubes disconnected and withdrawn, the grillage put in place, and the pier built.

The work was done rapidly, *of its kind*, the tubes of the first pier having been sunk and filled with the concrete foundation during the first season, and in the second season, that of 1861, the 16 tubes of the last four piers were put down.

Bridge at Orival.—The latest bridge founded with tubes, of which we have a description, is that over the Seine, at Orival, built in 1863 and 1864. Both the piers and abutments are formed of cast tubes, 11 feet 9 inches diameter, spaced 28 feet 6 inches between centres. The cutting section is 2¾ inches thick, the intermediate 2 inches, and the upper sections 1½ inches. The reader will find a full description of this bridge in *Engineering*, of February 1st, 1867.

The chief advantage offered by the use of the plenum process, lies in the complete command which it gives over the removal of obstacles. The process of excavating in compressed air, and of withdrawing the materials through an air lock, however, is both tedious and expensive. At the Theiss bridge, the workmen in the tube averaged only $\frac{9}{10}$ths of a cubic yard per day each, while as much as $15 per cubic yard has been paid by contract at other bridges. At Orival, the solid cubic contents of that portion of the columns sunk into the soil, averaged 147 cubic yards, and the average cost of sinking was $1786.46 each.

Where but few obstacles are to be expected, it may be much cheaper to employ other methods of excavation. Thus, in putting down tubes of 8 feet 4 inches diameter, to form the piers for the bridge over the Clyde, last year, Mr. Milroy sank them down 75 feet through sand, without the use of compressed air, and at a cost inside of one dollar per cubic yard removed, by the use of the ingenious machine figured and described in the number of *Engineering*, for December 6th, 1867; while wrought iron tubes 14 feet in diameter, have recently been sunk at one of the bridges now building across the Mississippi, by excavating inside with a vertical dredge, at a cost of about $750 per tube.

PART II.—CAISSONS.

In the improvements of the pneumatic process, which remain to be noticed, of substituting caissons for tubes, and putting in the foundations and building the pier simultaneously, the materials excavated have been withdrawn without passing through the air lock at all, while much greater rapidity of execution and stability of work have been secured.

Kehl Bridge.—When, in 1858, the governments of France and of the Grand Duchy of Baden, entered into an agreement for the purpose of building an international bridge over the Rhine, at Kehl, in order to unite their respective railway systems, it was at first contemplated to employ pneumatic tubes for the four river piers. Drawbridges being required adjoining each bank of the river, the piers next to the shores were to be of masonry, founded upon tubes, and the intermediate piers of columns carried up to the bridge seat.

The International Commission of Engineers, however, entrusted with the elaboration of the plans, came to the conclusion, that at this very difficult point, tubes would not afford sufficient stability.

The bed of the Rhine, at Kehl, is composed of sand, gravel and silt, of nearly indefinite thickness, in which scour is known to occur to a depth of 55 feet below low water. The stream is subject to frequent freshets, and sometimes attains a speed of 9 to 11 miles per hour; and it was feared that isolated columns, offering but little weight and base in proportion to their surfaces, might not resist the thrusts produced by unequal scour upon their opposite sides, and would offer but slight resistance to lateral shocks or shoves. It was besides objected to columns, that as but one tube could be sunk at a time, the founding of the four piers would occupy more than one season between freshets; that serious troubles had been experienced at other bridges in penetrating with tubes to a lesser depth than was thought necessary here (65 feet), and that besides the ungraceful architectural appearance of columns for the intermediate piers, as it would be necessary to give the iron great thickness to resist shocks, a large quantity of metal would be employed; and that it would be both cheaper and more expeditious to employ a different system.

Under these circumstances, the commission decided to adopt a modification of the pneumatic process, proposed by M. Fleur St.

Denis, the principal assistant engineer; which, although it did not realize the full measure of economy expected at the Kehl bridge, in consequence of the needless complications and difficulties always besetting a novel undertaking, was more rapid in execution, and has since, at other works, proved cheaper than tubes, while it affords very much greater safety and stability.

M. Fleur St. Denis proposed to sink down the whole pier of masonry to a depth of 65 feet below low water, by undermining and excavating under it, during the process of building, in an inverted plate iron caisson filled with compressed air, which should support the masonry above; and to withdraw the materials excavated through chimneys left in the pier.

It was arranged that the French Railway Company, of which M. Vuigner was chief engineer, should put in the foundations and build the masonry, while the Baden company, of which M. Keller was the chief engineer, should erect the iron superstructure. M. Fleur St. Denis was placed in charge of the foundation works.

The size of the foundations of the piers next to the shores, was 77 feet by 23, and of the intermediate piers 57 by 23 feet. It was at first proposed to build a single caisson for each, but some of the engineers consulted, feared that so long a body in proportion to its width might lurch in the process of sinking, and the space was divided into four separate caissons for the shore piers, and three for the intermediate piers,

Plates IV. and V. give a general idea of the process adopted, as carried out at the shore piers. The foundation was made of four independent inverted caissons of three-eighths boiler plate, each 19 feet long, 23 feet wide, and 12 feet high, placed side by side, so as to occupy a total length of 77 feet, and weighing in the aggregate, 306,000 pounds. In the roof of each were three openings, the central one 4 feet 11 inches in diameter, and the two lateral holes 3 feet 3 inches in diameter. The latter were surmounted with wrought iron pneumatic tubes, provided with internal ladders and winches, and served merely for the passage of the workmen, and the introduction of compressed air as well as materials for construction inside the caissons. Each air tube was used alternately, the air chamber being fastened to the one, while the other was in process of being lengthened; and thus a cause of considerable delay avoided. In the central hole a tube was inserted, passing down through the inverted caisson, and extending one foot below its bot-

tom edge; inside this tube a vertical dredge was mounted, which extended, as well as the air tubes, through the body of the pier up to the surface.

The four caissons having been built side by side, upon a temporary floor erected over the intended site of the pier, were lowered into the bed of the river by suspension screws supported by the staging, and the building of the pier begun on top of them. At first the caissons were disconnected from each other, and each surmounted with a wooden curb, lined outside with thin sheet iron, into which concrete was laid as fast as the sinking progressed; but after the experience acquired in sinking the first pier, the division into separate caissons, and the wooden curb, having been found useless complications, they were dispensed with; the four caissons were strongly bolted together, thus forming but one, with three internal partitions, in which man-holes were cut to facilitate the movements of the workmen, and the pier built in one mass of concrete on top of the caissons; the rubbing surfaces being faced with hammer-dressed dimension stone.

The caissons being thus placed on the river bed, which had been levelled off to receive them, and the pier built up on top of them, so as to reach above the surface of the stream, compressed air was forced through the pneumatic tubes into the caissons, and the water expelled.

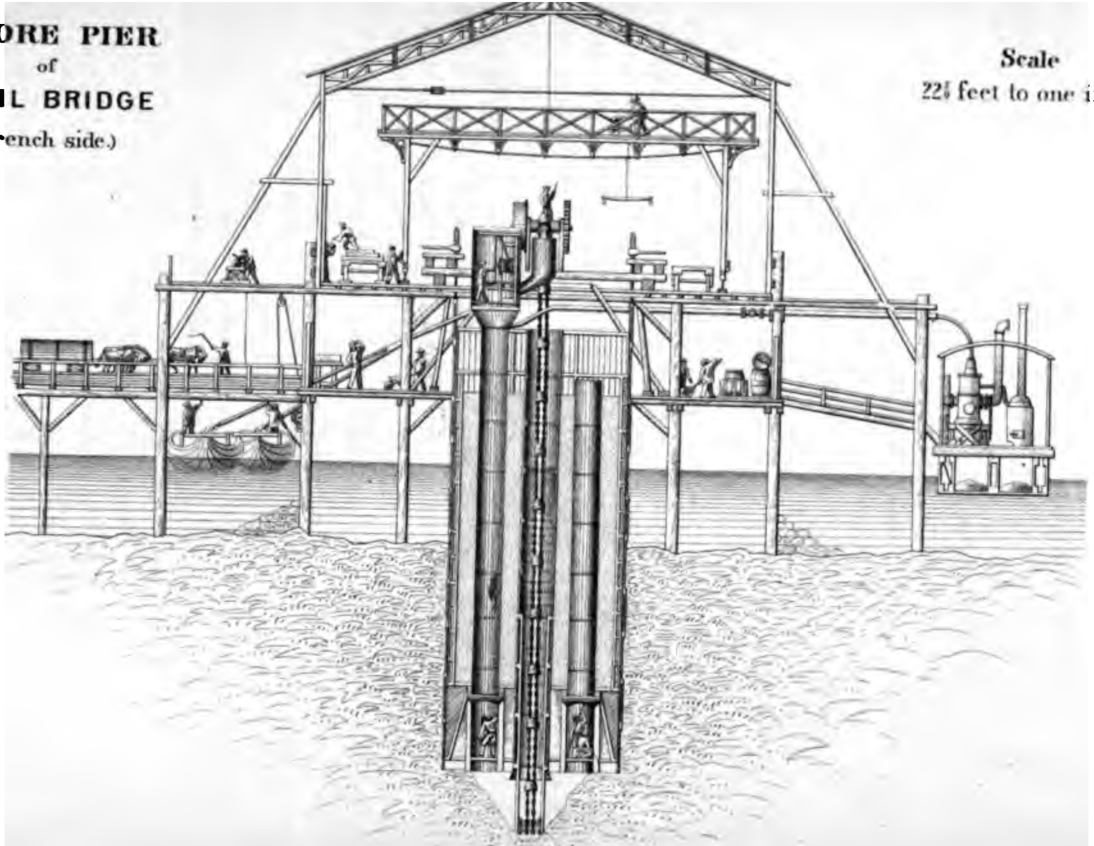
The central tube, in which the dredge was mounted, extending through and below the caissons, remained full of water at the same level as that in the river. Workmen were now introduced into the caissons, and standing upon a temporary floor, fastened to struts extending from side to side near the bottom, excavated the soil from the sides, and fed it under the edges of the central tube to the dredge, which raised it to the surface, whence it was conveyed in boats to the shore.

As there were thus to each of the shore piers, four dredges and eight pneumatic tubes, the work could be driven very fast. The first pier was put down in fifty-five working days, the second, profiting by acquired experience, in thirty-one; the third in twenty-five, and the last in twenty-four working days. The two latter being the intermediate piers, were of the reduced dimensions, were formed of three caissons, and had therefore but three dredges and six pneumatic tubes.

The piers were all put down to a uniform depth of 65 feet 9

SHORE PIER
of
KEHL BRIDGE
(French side.)

Scale
22½ feet to one inch.



Cross Section.

inches below low water, the greatest depth worked at below the stage of the river being 72 feet 9 inches, and the greatest pressure of air about 3 atmospheres.

When partly down, the pressure of the surrounding soil buckled the sides of some of the caissons. This had been provided for; masons were sent down into the inverted caissons, and built brick arches between the sides, so as to take up the thrust against them.

In order to have still water to work in, the site of the pier was enclosed in sheet piling, and so as to carry on the work night and day, in all weathers, a shed was erected over the works, with two working floors or stories 11 feet 6 inches apart, as shown in the plate. Traveling crabs traversed on the upper floor, and the materials were brought directly to the work by a double track railway, laid on a temporary wooden bridge.

The air compressing engines were five in number, of seventy-seven aggregate horse-power, and were placed upon boats on one side, while the other was reserved for the dredge boats. The four dredges were worked by two steam engines, each of ten horse-power, erected upon the upper working floor. The dredge buckets extending below the bottom of the tube in which they worked, excavated a hole beneath the lower edges of the caissons, into which it was easy to push the materials excavated by the workmen along the sides. The cubic contents extracted (4903 cubic yards on the average), varied from 1·63 to 1·72 times the actual cubic contents displaced by the pier, while in the tube process, three times the cubic contents has frequently to be extracted.

The chimney of 4 feet 11 inches diameter having been found too restricted to work the dredges successfully, the iron tubes were dispensed with above the top of the caissons, after the first pier, and an oval brick chimney built, 7 feet 6 inches by 4 feet 10 inches, for the dredge to work in. Similar brick rims were built a few inches from the pneumatic tubes, to preserve them from contact with the concrete, so that they could be removed by divers after the pier was sunk to the intended depth.

In order to regulate the descent and prevent lurches, the suspension chains, which were fastened to the bottom of the caissons, were lengthened from time to time, and fed down gradually by screws worked by ratchet levers at top, as fast as the undermining of the pier proceeded. The masonry was built so as to keep the weight but slightly in excess of that required to overcome the friction, and

within the power of the screws to sustain. Thus, at the beginning of the operation of sinking the pier next to the Baden shore, the state of equilibrium was as follows:

Depth of immersion of caissons below the water, which was on that day 6·72 feet above low water	18·23 feet.
Depth of penetration into sand	7·67 "
Height of masonry above roof of caissons	15·15 "
The water being expelled, the lifting reaction was	2,249,808 pounds.
And the load to overcome it and the friction was	4,049,523 "

When this pier was put down to depth, the equilibrium was as follows:

Depth of immersion (water 4·75 above low water)	70·45 feet.
Depth of penetration into sand	40·37 "
Height of masonry above roof of caissons	47·82 "
The reaction of the compressed air was	7,345,162 pounds.
And the load to overcome it and the friction was	14,757,328 "
The rubbing surface in contact with the sand was	9,666 square feet.
And the useful load to overcome friction	767 pounds per square foot.

Theoretically, the friction should increase as the square of the depth, but an examination of the daily journal of sinking and equilibrium kept at the Kehl bridge, from which the above is extracted, as well as recent experience in some of our western rivers, show that this is not strictly the case, and that considerable discrepancies are caused by the variations in the character of the materials penetrated, the natural arches sometimes formed by the soil, and the difference between its friction of rest and friction of motion.

It will be noted that about one-half the useful effect of the weight was absorbed by the reaction of the compressed air, which was to that extent a detriment in sinking, while its use required powerful and complicated machinery, and added materially to the expense. The cost of excavating the materials with the dredges, was $3.84 per cubic yard, a material reduction over the cost in tubes, yet much more than it would be in open air. The chief value of the compressed air lay in the command it gave over the removal of obstacles, of which few fortunately were found in sinking. Two logs were met with under one pier, which were readily cut through, some brush-wood under another, some iron anchors were also found, and at a depth of forty-seven feet below low water, links of a chain, large nails, part of a horse-shoe, a knife, pieces of cast iron, &c.

The abutments were founded, by dredging in the open air, a pit

to a depth of thirty-nine feet below low water, allowing the material to assume its own slope, sliding a wooden caisson into position, filling it with concrete, and rip rapping outside. These abutments carry the turn-tables of the pivot bridges, one leg of each of which extends over the stream, and the other over the land.

In order to save the very considerable weights of iron in the caissons, M. Fleur St. Denis had proposed a further modification of his process, which consisted of making the caisson practically a diving bell lowered down through sand instead of water. He proposed to force it down by loading it with sand and water instead of the masonry of the pier, and after the desired depth was attained, to build the pier *under* the caisson in compressed air, gradually unloading and raising the latter as fast as each course was laid. This, although not impracticable, was thought to present such numerous chances of accident and delay, that it was not adopted, and it was preferred to carry out the original designs in which the caissons were allowed to remain under the masonry of the pier, and were filled with concrete as soon as the desired penetration was reached.

Notwithstanding this rapid method of putting in foundations, the bridge was a considerable time in building. Work was started in July, 1858, the operation of sinking the first foundation was begun in March, 1859, and the bridge opened to the public in April, 1861.

The cost of the Kehl bridge was as follows:

Grading, dredging, and preparing working yards....	$ 36,735
Temporary bridge and scaffoldings....	148,800
Foundation and masonry of shore pier, French side....	141,360
" " " " Baden "	117,180
" " " inter. " French "	93,930
" " " " " Baden "	92,070
" " " French Abutment....	114,150
" " " Baden "	140,430
Accessory works, river landings, &c....	27,900
General expenses and superintendence....	33,945
Iron superstructure for double track railway bridge....	325,500
Total cost....	$1,302,000

Which is of course very expensive for a bridge 771 feet long between abutments, or taking into account the legs of the two draw-bridges which project over dry land, 1013 feet over all.

The mode of founding adopted at the Kehl bridge, was thus the origin of an important improvement in the pneumatic process. It

substituted one single mass of masonry for isolated columns, and thus added much to the stability. It made the weight of the pier useful in sinking, so that it could be built simultaneously with the excavation of the foundation, and substituted dredges for the former tedious and expensive mode of raising the excavated materials in bags or boxes. At every bridge where it has since been applied, its cost has been less than that of tubes giving the same area of base, while its permanency must be greater, and the cost of repairs less than those of any supports relying upon metallic envelopes. It can be applied equally well to the sinking of stone columns surmounting a round pneumatic caisson, and in some instances where companies had previously supplied themselves with tubes, these were altered so as to be sunk by the modified process with advantage.

Voulte Bridge. At the bridge over the Rhone, at La Voulte, the experience acquired at Kehl was utilized as follows:

The working chamber, instead of being divided into several compartments or independent caissons, was composed of a single inverted caisson $\frac{7}{16}$ths thick, and 8 feet 6 inches high. In order to permit the height of the masonry to be adjusted at all times to the weight required, the working chamber was surmounted with a coffer-dam or iron caisson $\frac{3}{16}$ths thick, carried up above low water, inside of which concrete was poured. The materials were excavated by a single dredge, placed in the centre, and the workmen went in and out through two air tubes.

The pier was, as at Kehl, suspended to lowering screws, which regulated its descent.

(To be continued.)

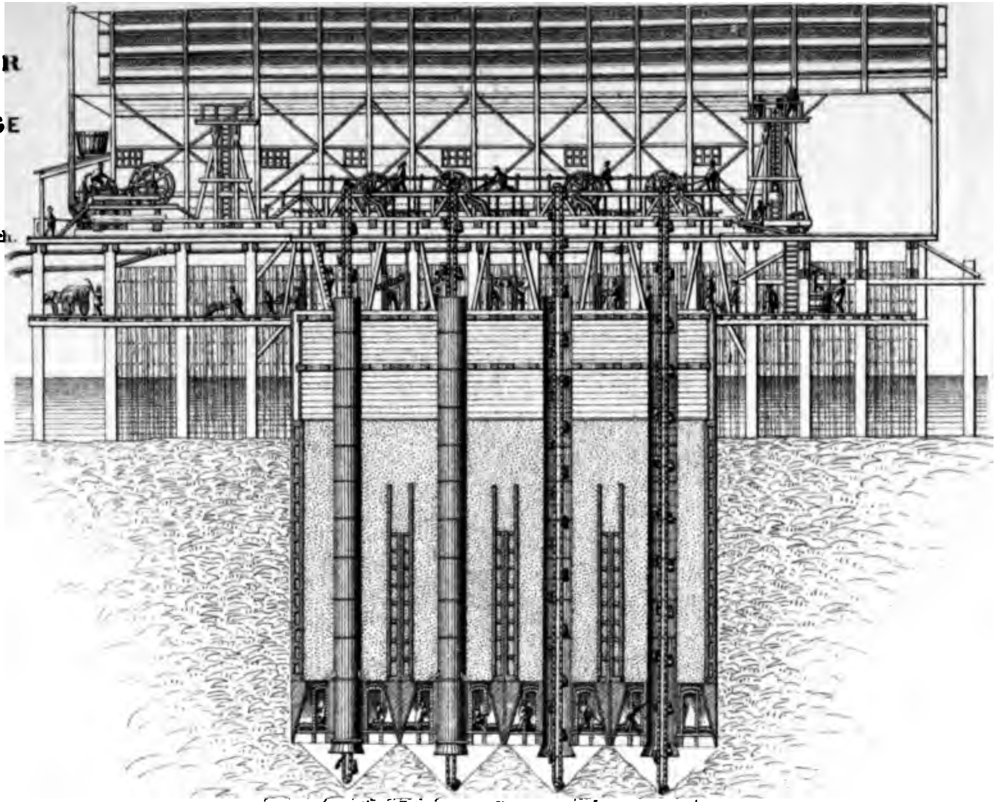
SUEZ CANAL—SUPPLEMENT.

By Chas. H. Rockwell.

The following calulations were made by Mons. Lavalley, with regard to the time which will be required to fill up the immense area known as the "Basin of the Bitter Lakes." The extreme length of this depression is about 22 miles, varying in width from 2½ to 5 miles. The maximum depth is about 35 feet below the sea level. This basin is now dry, and has been so from the time of the earliest traditions. The bottom is now covered with a deposit of salt, from 6 to 20 inches in thickness, and the formation of the country

SHORE PIER
of
KEHLBRIDGE
(French side.)

Scale.
33⅓ feet to one inch.



Longitudinal Section.

shows conclusively that this was formerly the head of the Red Sea, and Mons. de Lesseps brings strong arguments in support of the idea, that here was the point of crossing by the Israelites, under the guidance of Moses and Aaron.

The surface area of this Basin is 170 million square metres; its cubic capacity is a thousand million cubic metres. The Mediterranean end of the Canal will soon be so far advanced as to give a cross-section equal to 200 square metres. This with a current of 11 inches per second will deliver a volume of more than five million metres per day. An allowance of a million and a half cubic metres per day is made for evaporation, and a total allowance of six hundred million cubic metres for loss by saturation—at the rate of three cubic metres for each square metre of the bottom. At this rate about 400 days will be required for filling. But the Suez end of the Canal will be so far finished before this period has elapsed, as to bring in about two million cubic metres per day, from the Red Sea; which will reduce the time to 250 days.

The capacity of Lake Timsah is about eighty million cubic metres, and the water from the Mediterranean has been flowing into this basin since December, 1866.

The greatest depth here is about twenty feet below the sea-level. This was formerly a fresh water lake, supplied by the overflow of the Nile, but has been entirely dry for ages. Henceforth, it will be a saltwater basin, supplied from the sea at either end of the canal.

The town of Ismailia, on the bank of the lake, has already a population of 4000 inhabitants.

The following facts may aid us in forming some idea of the possible or probable revenues of the Suez Canal.

About three million tons of shipping now annually double the Cape of Good Hope, engaged in the trade between China and India, in the East, and Europe and this country, in the West.

The rate of freight by railway between Alexandria and Suez, is now from 70 to 200 francs per ton, according to its classification. The Peninsular and Oriental Company, and the Messageries Imperiales pay about half these rates. The last named company are now sending their coal through the Canal at a cost of about 21 francs per ton, and at 25 francs per ton for heavy merchandize.

The saving in distance between the route around the Cape of Good Hope, and through the Canal, is shown in the table below.

The Island of Ceylon is chosen for the eastern terminus, in these calculations, as representing a point of mean distance in the Asiatic seas.

	Distance in Graphic Miles.		Per cent. of Saving.
	By Cape.	By Suez.	
London	14,340	7,300	49
Marseilles	14,500	5,490	62
Trieste	15,480	5,220	65
New York	15,500	9,400	40

The original capital of the company was two hundred million francs in four hundred thousand shares.

As subscribed for in November, 1858, they were distributed as follows:

France	207,000	shares.
Egypt	96,000	"
Austria	51,000	"
Russia	24,000	"
England	5,000	"
United States	5,000	"
Spain	4,000	"
Netherlands	2,000	"
All other countries	6,000	"
	400,000	shares.

The viceroy of Egypt now owns about 177,000 shares.

RECEIPTS OF THE SUEZ CANAL.

1st Quarter, 1867		255,149	francs.
2d "	"	262,752	"
3d "	"	300,321	"
4th "	"	474,597	"
1st "	1868	544,961	"

Mechanics, Physics, and Chemistry.

CORNISH PUMPING-ENGINES.

THIS class of engine is especially interesting on account of its superior economy of fuel. The conditions involved by which its pre-eminence, in this regard, has been attained, may be looked for in the following:

1. The high degree to which expansion may be advantageously employed.
2. The unfettered state of the piston, allowing celerity of action.
3. The saving of steam from loss by clearance, and steam passages.
4. The isolation of the working end of the steam cylinder from the cooling influence of the condenser.
5. The turning to direct account of the *vis viva* of the moving masses of the machine. Another source of economy is directly traceable to the use of the "Steam Jacket," an invariable adjunct to this class of engine.

Presuming that the reader is already acquainted with the peculiar construction of the Cornish pumping engine, and its manner of operation, the classified points of merit will next be reviewed. "The high degree to which expansion may be advantageously employed, in connection with the unfettered state of the piston, allowing celerity of action," is peculiarly adapted to the purpose of pumping water. Steam is admitted at the commencement of the stroke; up to the point of cut-off, the velocity of the weight is uniformly accelerated; the momentum acquired, together with the force given out by the expansion of the steam, carries the piston to the end of its stroke, when the resistance and pressure will coincide

In the out-stroke, the weight of the pump-plunger descends with a constant resistance, and consequently with a uniformly augmented velocity, and the momentum acquired is again stored up at the end of the stroke, in the steam contained above the piston, to be made available in the return stroke. Now, expansion, if carried to any considerable extent, necessitates the use of a high pressure of steam; its extended application, therefore, to a rotative pumping engine, is, strictly speaking, not admissible, owing to the varying speed given out by the steam expanding from a high initial pressure, to the low

degree at which the terminal pressure should be brought, having economy in view. This variation of pressure must be highly injurious, especially where the load is not susceptible of acquiring momentum, as is the case, to a considerable extent, in pumping water. From this, it will be seen, that a steam-engine designed for driving mill shafting, or other rotating machinery, where a uniform speed of revolution is necessary, would be entirely misapplied if put to pumping water. In the first case, a uniform speed of fly-wheel is indispensable, while in the latter a uniform speed of piston is required, extremes which never can be produced in connection. As a consequence, then, the fly-wheel must either govern the motion of the pump, or else the pump must govern the motion of the fly-wheel, and the latter, to be of any use at all, must be heavy enough to carry the engine over its centres, when running at a low rate of speed. In order to do this effectually, it must possess so much weight as invariably to make subsecutive, the primary object aimed at. It is true the employment of a heavy fly-wheel, counteracts to a certain extent, the varying pressure of the expanding steam; but the succession of shocks given out to the piston, by the admission of the steam, and its attenuated power at the end of the strokes, tells heavily upon the engine, in spite of the fly-wheel's modifying effect. And a tendency to break down can only be avoided by making the engine very heavy, and consequently expensive.

The evil effects of the irregular action of the pump plunger, can also be partially averted, by the use of a large air-vessel; a reservoir into which any excess of water delivered by the pump when working at its maximum velocity, is stored up to be given out again, when the pump is at its minimum speed, or passing its centres. The irregularities and internal struggles may be nicely smoothed over to the eye of the superficial observer, by the devices just described, but they will nevertheless exist to a damaging extent, and become manifest in due time in the matter of costly repairs, and heavy coal accounts.

We now pass to "the saving of steam from loss by clearance and steam passages, and the isolation of the working end of the steam cylinder from the cooling influence of the condenser." In the Cornish engine, that end of the steam cylinder where the steam is admitted from the boiler, never has any communication with the condenser. Steam being admitted at the commencement of the stroke, follows the piston up to the point of cut-off. The balance of the stroke is completed

by the combined aid of expansion, and the momentum acquired by the mass of material set in motion. The steam is then allowed to pass freely from one side of the piston to the other, producing an equilibrium of effect, during the out stroke. Before the piston arrives at the point of commencement again, the equilibrium valve is closed, shutting in a quantity of steam before it. It is evident that by means of this cushioning, the loss from clearance, and steam ports, is rendered practically nothing, if the steam so compressed be equal to the initial pressure. The piston is thus gradually brought to a neutral state at the end of the stroke, when the exhaust valve opens a communication between the *opposite side* of the cylinder, and the condenser *only*.

This is very different in all other descriptions of steam engines, where heat is abstracted at every single stroke from the metal of the cylinder, by the chilling influence of communication between it and the condenser, which lowering of temperature, must be raised again, at the expense of the entering steam. A certain quantity of heat passing thus, at each stroke, from the boiler, through the cylinder to the condenser, without contributing in any manner to the performance of work. And this effect is increased directly by a further liquefaction of the expanding steam, above that due to the loss by expansive working, the very presence of such an additional amount of condensation increasing at once the evil.

The next point to be considered, is "the turning to direct account of the *vis viva* of the moving masses of the machine." It would be paradoxical to suppose that more power could be given out by a moving weight, than the original force which created it. And it has been urged that nothing can be obtained from the momentum of the swinging masses of the beams, and heavy pump-tree, and balance-bob, more than a mere return of the force that started it in motion. Such an argument is perfectly valid. And all we claim for the Cornish engine is, that such a return is faithfully made, which is not the case with any other description of engine. One of the most important features in the Cornish engine, and on which depends its successful operation, is to proportion the gravity of the moving mass in strict accordance with the point at which the steam is to be cut off. A neglect of this invariable necessity, rendered the first Brooklyn pumping engine a complete and costly failure.

When the steam is first admitted to the piston, the force is much greater than is required to raise the heavy weight of the pump

plunger, consequently a very rapid motion is imparted, and the piston will be carried to the end of its stroke, by the acquired momentum. Although the pressure is not sufficient, near the end of the stroke, to balance its weight, the potential energy is gradually converted into actual work, until the end of the stroke, when it should be entirely exhausted, the terminal pressure will then just equal the load and back pressure. As a further proof of the advantage of a heavy moving mass, it has been found in practice, that "Bull Engines" are invariably inferior in duty to the beam variety, and that the latter description vary in their duty in proportion to the amount of metal distributed in the moving parts.

No such advantage as the above can accrue to the rotative engine; for whatever momentum the piston and its connections may possess at the end of the stroke, is entirely lost, being expended on the crank-pin, at the dead point, where no pressure whatever could produce any good effect.

Neither can any such results be obtained from the variety of direct acting steam pumping engines, from the simple fact that the steam cannot be used expansively to anything like the beneficial extent afforded by that principle. The terminal pressure must invariably be fully equal to the load, or the pump will come to a dead stand. It would be exceedingly difficult, in practice, to maintain the initial pressure precisely at a certain point. And in order not to fall below it, knowing the consequence, the disposition would be to carry an excess of steam above that necessary to perform the work; which excess of potential energy will be discharged at each stroke into the atmosphere, or condenser, the engine being high or low pressure. The last feature of presented economy, is to be found in the use of the "steam jacket," a casing of cast iron, enveloping the steam cylinder, having an annular space between the two of about one inch, which space is constantly supplied with steam from the boilers, maintaining the temperature of the metal of the cylinder to an extent preventing the liquefaction of the steam working expansively within the cylinder.

When work is done by expansion, heat must necessarily disappear and manifest itself in a fall of temperature, producing liquefaction; the rate of expansion being duly accompanied by a corresponding fall of temperature. Steam becomes liquid in a naked cylinder, simply by the heat passing off to the outside air, and the effect is indirectly increased by the extent of saturation produced

in expansive working, as moist steam being a better conductor of heat than dry, parts with its heat more rapidly to any neighboring conducting material of a lower temperature. It is not by the addition of a steam jacket that the evil of condensation, attendant upon the rate of expansion, can be averted, as this will necessarily take place from the constancy of natural laws; but the liquefaction will take place in the steam jacket, instead of the cylinder, with entirely different results. Condensation in the former case can do no serious harm; for instead of being lost in the condenser, and carrying off heat, it is returned to the boilers by a return pipe, proceeding from the bottom of the jacket.

From the results of extended practical observation of the duty developed by the various descriptions of English pumping engines, the Cornish stands pre-eminent for its remarkable economy; the duty in one case, having amounted to 130,000,000 pounds of water raised one foot high by 112 pounds of coal. Future developments looking to an increased rate of economy, may be looked for in the possible adaptation of the compound principle applied to the Cornish type.

W. M. HENDERSON,
Hydraulic Engineer.

Philadelphia, May 9th, 1868.

PATENTING A PRINCIPLE.

(Concluded from page 414.)

It is unnecessary to go through all the cases in the English books to which this explanation applies. One, which was determined by our own Supreme Court, deserves to be noticed here, especially because it was considered at the same term with O'Reilly *v.* Morse, and both must have been together in the minds of the judges—that of Winans *v.* Dennacad, 15 How. 330. The plaintiff's invention consisted in constructing coal-cars in the form of the frustum of a cone. The defendant's cars were octagonal instead of circular, but otherwise resembled the plaintiff's. One of the judges inclined to the opinion that the plaintiff was, by the terms of his patent, limited to the precise form he had described, and could have no remedy against others who used a different one. It was shown that there was no practical difference between the two; but either

would derive especial strength from the mechanical law involved. And, though the plaintiff's claim was, in express terms, to the frustum of a cone; though he did not pretend to claim the mechanical law thus applied, the defendant was held to have violated his patent. This could not be on the ground that the principle of mechanics was patented. It must have been on the ground that the form adopted by the defendants was a mere equivalent for that of the plaintiff.

It may be said that what have been designated as mechanical laws in the preceding pages, are in truth laws of nature, physical just as much as the properties of matter, and that the two classes run into each other, so that no distinction can be made between them. It is not necessary to insist that there may be in theory. In practice, there is a radical difference which fully justifies their being considered as belonging to two classes. In the case of inventions founded on what have been termed mechanical principles, the patentee obtains full protection in the exclusive enjoyment of the principle by being allowed an action against every one who uses an equivalent for his device. No machine can be constructed on the principle of his which does not embrace such equivalents. It may not be so where the novelty of the invention consists in some property of matter first brought to light by the patentee. Neilson's patent covered the use of a vessel for heating air placed between the blower and the furnace—not the introduction of heated air into the furnace, which was truly his discovery. If any one could have contrived to heat the air sufficiently before it entered the blower, he might have availed himself of Neilson's discovery with impunity. The difficulty of doing this constituted the whole strength of his patent. Anybody might have availed himself of the quality of lead discovered by the Tathams, if he could have got up a machine of a different construction. It is very possible that the courts may give a larger range to the doctrine of equivalents, in order to secure to the discoverer of a new physical property an adequate reward for his ingenuity. Thus far, it is only as the defendant has been found to have employed mechanical equivalents for the construction specified by the patentee, that he has been held guilty of infringement, or the patentee has obtained protection.

There are a few other cases upon this subject which are not open to the explanation given to those heretofore mentioned, and which may be thought to require a passing notice.

The plaintiff in Forsyth *v.* Riviere, 1 W. P. C. 97, after describing in his specification the explosive compounds employed by him in igniting the charge in fire-arms, added: "I do not lay claim to the invention of any of the said compounds," &c., "my invention in regard thereto being confined to the use and application thereof to the purposes of artillery and fire-arms as aforesaid. And the manner of priming and exploding which I use is," &c., proceeding to describe it. There was no specification of claim. It is manifest that this patent was for the method he employed. It is true that the reporter says the defendant's lock was constructed differently; but he does not furnish the slightest intimation in what respect it varied. The note of the case is very short and unsatisfactory. The report, bearing the same title in Chit. Pr. C. 182, is upon another point entirely. But from the statement of the counsel in Minter *v.* Wells, W. P. C. 128, we learn that all the difference between the locks was this: in the patentee's the hammer struck the pan containing the composition, and in the defendant's the pan struck the hammer.

No one can read the patent of the plaintiff in Hall *v.* Boot, 1 W. P. C. 100, without perceiving that he laid claim to his machinery when used in connection with gas flame. There was no positive evidence what machinery the defendants used, it is true; but this does not warrant the inference that the court recognized the plaintiff's title to the exclusive use of gas flame with any machinery for the same purpose. There was circumstantial proof of the strongest kind that the defendant's was borrowed from the plaintiff's, and was identical with it.

The claim set up in Booth *v.* Kennard, 1 Hurls. & N. 527, was for "making gas direct from seeds and matters herein named for practical illumination, or other useful purposes, instead of making it from oils, resins, or gums previously extracted from such substances." Upon the trial of the case, POLLOCK, C. B., held this claim to be too broad, and directed a verdict for the defendant. The verdict was set aside in the Court of Exchequer Chamber; and from the report it would certainly seem as if the court considered the patent valid. But when the cause came on for trial again before Chief Baron POLLOCK, he said that the court had decided nothing more than this: that the invention "was one which, if new, might be patented if properly specified." He added, "we are also of opinion that the claim is too large, and that such claim cannot be

supported." There was a verdict for the defendant again. But as there was also strong evidence upon that trial that the invention was not new, the plaintiff probably deemed it unsafe to proceed any further, after moving that a verdict should be entered up for him, and being denied. Little or no reliance is manifestly to be placed on the report of the decision in the Exchequer Chamber, after the explanation given by Chief Baron POLLOCK.

The plaintiff in Seed *v.* Higgins, 8 Ell. & Bl. 755, 771, and 6 Jur. N. S. 1264, had originally taken out a patent for the application of the law or principle of centrifugal force to the particular or special purpose above set forth;" *i. e.* to fliers used for preparing, slubbing, or roving cotton, &c., so as to produce a hard and evenly compressed bobbin. He afterwards discovered that centrifugal force had been employed already for the same purpose, though by different means; and he therefore filed a disclaimer, by which he limited himself to the mechanism he had described in his specification. Upon this a a question arose whether his patent did not, when thus amended, appropriate a different invention from anything embraced in his original specification, and was not therefore void. The case was very fully discussed in several courts, but was finally decided against the plaintiff upon the ground that the defendant's machine was no infringement of the patent. In the course of delivering their opinions it was incidentally mentioned by one or more of the judges, that the defendant's machine came within the purview of the patent as originally framed. But there was no opinion expressed throughout as to the validity of the original patent, nor any allusion made to the subject. If it may be inferred from the silence observed respecting it that the validity of the instrument was admitted, there is some propriety in referring to the case when examining this doctrine. It will probably be regarded by most as of no weight whatever.

The court interpreted the second claim made by the plaintiff, in Bovill *v.* Keyworth, 7 Ell. & Bl. 724, to be for "exhausting the air from the cases of the millstones, combined with the application of a blast to the grinding surfaces." Upon this, Lord CAMPBELL, who presided, remarked as follows, viz.: "Still if the specification does not point out the mode by which this part of the process (No. 2) is to be conducted, so as to accomplish the object in view, it would be a statement of a principle, and the patent would be invalid." He held it to be sufficient, however. And it may well be doubted

whether it was fairly open to the objection that it would have been for a principle without a description of the process, though such a description was no doubt essential. The case belongs to a class which has been often supposed to involve the legality of patenting a principle, but really has little to do with it. A blast and an exhaust are two mechanical forces as well known as a stream of water or as steam. Every artisan skilled in the business is perfectly familiar with them, and knows how to produce them. The invention in this instance consisted in combining the two so as to produce a particular effect. After describing how this might be done, the specification defines the invention as consisting in the combination of these two forces, each applied to a particular and well known mechanism. In all this we see nothing like patenting a principle, and apprehend there was no foundation for the remark of his Lordship. He may have had an idea that the patent would have been defective in not specifying some visible structure as the invention; but that is very different from patenting a principle. The case has little or no bearing on that subject.

From this discussion and examination of the cases the following conclusions are legitimately drawn:

1. Every discoverer of a new and useful application of any law of nature, any quality of matter, or any mathematical principle, is entitled to a patent for it.

2. It is not necessary to entitle him to a patent, that he should have been the first to search out and make known the law, quality, or principle which he has thus applied. And his having been the first to bring it to light adds nothing to his claims.

3. He will be protected in his right by holding as infringements of his patent all mechanical equivalents for the devices for carrying his discovery into effect, which he has described and designated in his specification as his invention. And he can have no other protection, even though the principle he has applied was first discovered by him.

4. No one can legally specify as his invention, and take out a patent for the exclusive use of any such law, quality, or principle when employed for the same purpose as his. No instance can be found where any such patent has been sustained, and they have been repeatedly pronounced invalid by the courts.

S. H. H.

NITRO-GLYCERINE: ITS CLAIMS AS A NEW INDUSTRIAL AGENT.

By John Mayer, F. C. S.

Notwithstanding the lamentable occurrence at Newcastle, in December last, resulting, as it did, in the death of seven persons, and notwithstanding the fact, likewise, that nitro-glycerine has in three or four instances, in America, proved itself to be a dangerous compound when not properly dealt with, its advantages as a blasting agent have been so extensively and so satisfactorily demonstrated, during the last three years or so, that it is high time that industry should more generally step in and claim it as a new handmaid which science has placed within her reach. Already on the continent of Europe, and in America, this remarkable compound has established its claim to rank in the first place as an explosive agent; and it is the object of the present article to examine in a scientific and dispassionate manner its title to be regarded in that light, in such a manner, indeed, as shall, we hope, form a marked contrast to the wild panic-stricken editorials which were so numerous in the daily and weekly newspapers during the latter half of the month of December last. There would have been less need for this present "corrective," if certain scientific journals had not also run riot immediately after the Newcastle explosion, instead of showing that their guiding minds were possessed of the spirit of true scientific acumen and a desire to aid industrial progress in the fullest sense of that term.

It is not undesirable to refer, although very briefly, to the history and manufacture of nitro-glycerine, so as to carry our readers along with us intelligibly to the conclusion of our remarks.

Nitro-glycerine has been known as a blasting material in the operations of mining, quarrying, and railway-cutting, for about three years; but it is fully twenty years since it was discovered by a young Italian, M. Ascagne Sobrero, while he was a student in the laboratory of the well known French chemist, Pelouze. Briefly, it may be stated that Sobrero obtained it as a result of the action of a mixture of strong nitric and sulphuric acids on glycerine. He examined it somewhat minutely, as also did several other chemists, continental and British. Amongst them Dr. J. H. Gladstone is not unworthy of mention. He reported at considerable length regarding it to the Chemical Section at the Cheltenham Meeting of the British Association.*

In course of time many facts were noted with reference to its true chemical nature and its chemical and physical properties, the chief of which, of course, was its great explosiveness, or rather its great power as an explosive compound. The practical utilization of this property was left for Mr. Alfred Nobel, a Swedish mining engineer.

* British Association Reports, 1856.

He was quick enough to observe that it might possibly be used in mining operations, and scientific enough to discover how it could be manufactured on the large scale, chemically pure, and always of the same quality in every respect. Former observers had been much troubled with it, owing to its instability, its tendency to decompose spontaneously, and generally with explosive violence. All chemists who know anything of the early history of gun-cotton will remember that chemical instability and spontaneous decomposition were almost invariably associated with it. Some French chemists still regard it as a very unstable, and, therefore, unsafe substance; but Von Lenk and Professor Abel have amply demonstrated that, if thoroughly cleansed raw cotton be used and every trace of acid be removed from the manufactured product, the tendency of gun-cotton to spontaneous decomposition is completely overcome. Nobel did exactly the same for nitro-glycerine, and its manufacture soon became in his hands one of the practical arts. He secured patent rights for his process of manufacture in most European states, and himself settled down on the Elbe, in the vicinity of the city of Hamburg, as a manufacturer of the new explosive, or "blasting oil," as he chose to call it.

There are now five establishments in existence—collectively aged eleven years—where nitro-glycerine is manufactured on the large scale. They are at Lauenburg (Prussia), the one just referred to as outside the city of Hamburg, at Stockholm, Christiana, Helsinfors, and New York. In order to reduce to a minimum the danger which is alleged to attend the manufacturing operations, the establishment first mentioned is wholly built in an artificial excavation in and beneath the level of the earth; and thus any explosion which may possibly result in the works will be confined to the works themselves, and will exert no damage in a lateral direction. This plan might well be adopted in building gun-powder mills. As an indication that the manufacture of nitro-glycerine is conducted on an exact system, on rigidly scientific principles, it may be mentioned that in only one instance has there been an explosion in any of the five works mentioned, and even that was but a very slight one. The manufacture has not yet been introduced into England, although we carry on mining operations, quarrying, railway-tunnelling, &c., on such a stupendous scale as is not excelled in any country of similar extent. Why English capitalists have not taken to it we know not; but of this we feel assured, from what we know of the extent to which nitro-glycerine is already in use amongst us, that the manufacture of this substance is yet destined to become a profitable undertaking in this country, when its use will doubtless be very greatly extended.

As might almost be inferred from the name, and, indeed, as has already been mentioned, nitro-glycerine results from the action of nitric acid on glycerine; at all events, the chemistry of the opera-

tion is essentially limited to the reaction of those two substances on each other. In practice, it is found necessary to use sulphuric acid in conjunction with the nitric acid, as in the production of gun-cotton. The essential details of the chemical transformation are the following, according to M. Kopp and various other chemists:—Fuming nitric acid (sp. gr. about 1·52) is mixed with twice its weight of the strongest sulphuric acid, in a vessel which is kept cool by being surrounded with cold water. When this acid mixture is properly cooled, there is slowly poured into it rather more than one-sixth of its weight of syrupy glycerine; constant stirring is kept up during the addition of the glycerine, and the vessel containing the mixture is maintained at as low a temperature as possible by means of a surrounding of cold water, ice, or some freezing mixture. It is necessary to avoid any sensible heating of the mixture, otherwise the glycerine is to a large extent transformed into oxalic acid. When the action ceases, nitro-glycerine is produced. It forms on the surface as an oily-looking fluid, the undecomposed sulphuric acid forming the subjacent layer, owing to its greater specific gravity. The whole mixture is then poured, with constant stirring, into a large quantity of cold water, when the relative specific gravities become so altered that the nitro-glycerine subsides and the diluted acid rises to the surface. After the separation in this manner into two layers is effected, the upper layer may be removed by the process of decantation or by means of a siphon, and the remaining nitro-glycerine is washed and re-washed with fresh water till not a trace of acid reaction is indicated by blue litmus paper. The final purifying process pursued by Mr. Nobel,* is to crystallize the nitro-glycerine from its solution in wood naphtha. Every chemist knows that by this means the substance will be chemically pure and of uniform composition and quality.

Before enlarging on the properties of nitro-glycerine and its applications, we may just glance at its chemical nature for a moment or two. Glycerine is a ternary compound, a sort of oxidized hydrocarbon, its formula in the ordinary notation being $C_6\,H_8\,O_6$. The combined action of the strong sulphuric and nitric acids is to transform it into a quaternary compound, a substitution product, in which three equivalents of peroxide of nitrogen ($3\,NO_4$) are substituted for three equivalents of hydrogen, which are removed during the reaction. The chemical constitution of nitro-glycerine may therefore be indicated in the following manner:—

$$C_6 \left\{ \begin{matrix} H_5 \\ (NO_4)_3 \end{matrix} \right\} O_6, \text{ or } C_6\,H_5\,(NO_4)_3\,O_6.\dagger$$

As a substitution-product, or *nitro-compound*, nitro-glycerine very

* Letter in "The Times," 27th December, 1867.

† Mr. Nobel regards nitro-glycerine as having the following composition (ordinary notation):—$C_6\,H_5\,O_3\,(NO_5)_3$, and alleges as a reason, that a solution of caustic potash will decompose the nitro-glycerine, resolving it into glycerine and nitric acid, and, with the latter, forming nitrate of potash.

much resembles gun-cotton, the *nitro-cellulose* of the chemist; indeed, it may almost be regarded as liquid gun-cotton; and certainly it has a great amount of interest for the scientific chemist, as much even as for the practical man who employs it as an industrial agent.

As prepared in the manner already mentioned, nitro-glycerine is an oily looking liquid, of a faint yellow color, perfectly inodorous, and possessed of a sweet, aromatic, and somewhat piquant taste. It is poisonous, small doses of it producing headache, which may also be produced if the substance is absorbed into the blood through the skin, and hence it is not desirable to allow it to remain long in contact with the skin, but rather to wash it off as soon as possible with soap and water. Glycerine has a specific gravity of about 1·25–1·26, but the nitro-glycerine has a specific gravity of almost 1·6, so that it is a heavy liquid. It is practically insoluble in water, but it readily dissolves in ether, in ordinary vinic alcohol, and in methylic alcohol or wood spirit. If it be simply exposed to contact with fire it does not explode, although it is so powerful as an explosive. A burning match may be introduced into it without producing any explosion; the match may be made to ignite the liquid, but combustion will cease as soon as the match ceases to burn. Nitro-glycerine may even be burned by means of a cotton-wick or a strip of bibulous paper, as oil from a lamp, and as harmlessly. It remains fixed and perfectly unchanged at 212° Fah.; if heated to about 360°, however, it explodes. Kopp says that it may be volatilized by a regulated heat without decomposition, but if it boils, detonation becomes imminent, and hence, when it is dropped on a metal plate which is hot enough to cause it to boil it will decompose with a somewhat violent detonation. A plate not actually red-hot will cause this change; if, however, the plate be red-hot, a drop of nitro-glycerine falling on it will immediately take fire and burn like a grain of gunpowder. At temperatures below from 43° to 45° Fah., it becomes a glassy crystalline mass, but is otherwise unchanged. It was crystallized nitro-glycerine which exploded on the Town Moor of Newcastle. Notwithstanding the great quantity of oxygen which is contained in this substance, and the powerful affinity which phosphorous and potassium have for that element, they have no effect on nitro-glycerine. If prepared perfectly pure, it is totally devoid of any tendency to volatilize, and it may be kept for an indefinite period of time without showing any proneness to spontaneous decomposition.

Nitro-glycerine may be decomposed with the greatest of ease by treatment with caustic potash, which resolves it into glycerine and nitric acid. This is certainly the most effectual means of rendering it permanently harmless, although there are other substances which will bring about its decomposition without any explosion. The extraordinary power exerted by nitro-glycerine during its explosion is undoubtedly the most interesting property which this substance possesses. The practical utilization of this explosive power

was at first thought impossible, because it was observed that a spark would not produce any explosion at all, and that a blow from a hammer or some similar instrument would only produce a detonation that was limited exclusively to the part struck. In using all other ordinary explosives, such as gunpowder and gun-cotton, it is practically necessary to employ fire, either as a spark or a flame, and as this would be of no use in the case of nitro-glycerine, some other mode of exploding it had to be resorted to. Mr. Nobel, who was the first person to demonstrate the possibility of using nitro-glycerine as a new industrial agent, hit upon the method now universally adopted, namely, percussion, or rather concussion. When a quantity of nitro-glycerine is spread in a thin layer over the surface of a hard stone, an anvil, or other metallic mass, and then *percussed*, or sharply struck with a hammer, only that portion actually struck explodes or detonates, so that percussion pure and simple is practically useless. The whole mass of explosive liquid must be violently *concussed*, and to produce the required concussion, the nitro-glycerine must be in a confined space, while, immersed in the liquid, there must be a small bag of gunpowder, or a percussion cap of extra strength, firmly fixed on the end of a gunpowder fuse. Thus it will be seen that nitro-glycerine almost requires to be coaxed into an explosive mood; and if people could only be brought to look on the explosions at Newcastle, San Francisco, Aspinwall, and one or two other places, without prejudice, it would universally be admitted that nitro-glycerine is not only not that frightfully dangerous material which many people in their ignorance believe it to be, and which some of them in a panic-stricken mood propose to "stamp out," but that it is even less dangerous than gun-cotton and gunpowder, and more completely under control than they are. We know that this is a very heretical and unorthodox utterance, still it is one that can be most indisputably supported and established by a great accumulation of facts resulting from the observations and experience of many persons whose minds are perfectly unbiassed.

Taking advantage of the circumstance that nitro-glycerine is soluble in wood spirit or methyl-alcohol, Mr. Nobel, nearly two years ago, made the happy discovery that it could almost instantaneously be rendered inexplosive, and that its explosiveness could be restored to it with equal readiness. The method of making it inexplosive is at once simple and effective. It is to mix with it from five to ten per cent. of wood spirit, when all attempts at exploding it are rendered utterly futile. Five per cent. of methyl-alcohol is said to be amply sufficient to transform the nitro-glycerine into the inexplosive or protected state, but Mr. Nobel now always adds ten per cent. before sending any of his blasting liquid into the market. A commission, appointed by the Hamburg Association for the Promotion of Arts and Useful Professions, made an extensive series of experiments on nitro-glycerine protected by the addition of

five per cent. of methyl-alcohol, in October, 1866. One of the experiments was an attempt to explode the liquid in the ordinary way with fuse and percussion cap. The experiment was twice repeated, but in neither case did the detonation of the cap affect the liquid. In another instance the protected liquid, in a tin bottle, was fired at with a bullet, but it was found impossible to produce an explosion. "In the opinion of the commissioners," the official report concludes, the protected blasting liquid "is perfectly inexplosive." When this protected liquid is exposed to heat in a proper vessel, the volatile solvent escapes, and in course of time, under the influence of a high temperature, the nitro-glycerine explodes, but not with the usual amount of violence, because, probably the explosion occurs before all the methyl-alcohol volatilizes. If protected nitro-glycerine be spread over the surface of an anvil, and then struck with a hammer in the usual way, it will not explode; after the lapse of some time, however, the explosive state is induced, owing to the evaporation of the solvent liquid.

(To be continued.)

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 405.)

9. *Inertia—Force.*

The property of matter by which it tends to retain its state, whether of rest or of motion, is called inertia.

By saying that a body has inertia, we merely understand that a body cannot *of itself* modify its condition, whether of rest or of motion; and that whenever a body begins to move, or to change the velocity or the direction of its motion, these changes in its condition are to be referred to some extraneous cause.

When a body is set in motion and abandoned entirely to itself—when it is conceived as being alone in space—it will move in *a straight line*, which is the direction of its first motion, and with its first velocity forever. This truth, called the law of inertia, is the result of an extended induction, and was not recognized before the time of Kepler. Descartes made it the foundation of his principles of mechanics.

Give illustrations of above principle, from observations of the motions of the heavenly bodies, and from experiments on the motions of bodies on the surface of the earth. The rotation of the

earth on its axis. A pendulum will vibrate two days in a vacuum, when the friction of the point of suspension is reduced to its minimum.

The apparent departures from the law of inertia, can all be referred to the action of forces or of resistances exterior to the body, and which are opposed to its uniform motion in a straight line.

Force.

All the phenomena, or changes which we observe in the condition of matter, are motions or the results of motions of either masses or of their ultimate parts or atoms; and that which produces these changes in the condition of matter is denominated *force.*

To Dr. Julius Robert Mayer, of Heilbronn, Germany, we owe the first successful attempt to give as clear conceptions in reference to force, as previously existed in relation to matter. In 1842, he published in *Liebig's Annalen*, a short paper of eight pages, entitled *Bemerkungen über die Kräfte der unbelebten Natur*, which from the fundamental importance of the truths which it unfolds, and from the results which have been deduced from them, is to be considered as one of the most important additions to knowledge produced in this century.

Mayer reasons thus: "Forces are causes; accordingly, we may in relation to them, make full application of the principle, *causa, æquat effectum.* If the cause c has the effect e, then $c = e$; if, in its turn, e is the cause of a second effect, f, we have $e = f$, and so on; $c = e = f \ldots = c$. In a chain of causes and effects, a term or a part of a term can never, as plainly appears from the nature of an equation, become equal to nothing. This first property of all causes we call their *indestructibility.*

"If the given cause, c, has produced an effect, e, equal to itself, it has in that very act ceased to be; c has become e; if, after the production of e, c still remained in whole or in part, there must be still further effects corresponding to this remaining cause; the total effect of c would thus be $> e$, which would be contrary to the supposition $c = e$. Accordingly, since c becomes e, and e becomes f, &c., we must regard these various magnitudes as different forms under which one and the same object makes its appearance. This capability of assuming various forms, is the second essential property of all causes. Taking both properties together, we may say causes are (quantitatively) *indestructible* and (qualitatively) *convertible* objects."

In another important paper, "*Bemerkungen über das mechanische Aequivalent der Wärme*, 1851," Mayer says: "*Force is something which is expended in producing motion;* and this something which is expended is to be looked upon as a cause equivalent to the effect, namely, to the motion produced."

Now, in these motions or effects, there are evidently two things to be considered, (1) the *mass* of matter moved, and (2) the *space* through which it is moved; and we have therefore force = mass × space gone through; but as we can *measure* and *compare* forces only by measuring and comparing their effects, and as bodies in free motion will move in the same right line, and with uniform velocity forever, we must place the moving bodies in such circumstances that their motions are destroyed, and we have remaining in their stead, equivalent effects, which we can *measure;* then the comparison of these measures will give us the relative intensities of the forces.

These effects, either directly or indirectly obtained from the moving body, are as various as there are kind of forces and resistances existing; thus, we may oppose to a body, moving vertically upward, the resistance of gravity (which we may regard as constant, if the upward flight of the body is a very minute fraction of the radius of the earth); or, we may oppose the constant resistance, which a body of homogeneous structure offers when it is penetrated by another, as, for example, when a cannon ball penetrates earth, clay, or pine wood; or, again, we may have, for the effect of the destroyed motion, *heat*, which makes its appearance whenever a moving body is brought to rest either by friction, percussion, compression, &c., with some other body, or, as in Foucault's experiment, where a copper disk being forced to revolve between the poles of a powerful electro-magnet, the motion of the wheel being opposed by the reaction existing between the electric currents flowing in it and in the magnet, the motion (force) lost by the wheel appears as heat (force) in its substance.

The heat which is produced by any of these means can readily be caused to evolve, as *it* disappears, dynamic electricity, light, and chemical action. Thus, in an experiment which the author devised for his classes, about four years ago, the *heat* developed by the "*falling force*" of a weight striking the terminals of a compound thermal-battery, formed of pieces of iron wire and German silver wire twisted together at alternate ends, caused a current of electricity through

the wires, which being conducted through a helix *magnetized* a a needle (which then attracted fine iron particles), caused *light* to appear in a portion of the circuit formed of Wollaston's fine wire, *decomposed* iodide of potassium, and finally *moved* the needles of a galvanometer.

Let us now try to arrive at comparable measures of force by first opposing to the moving body the constant resistance of gravity, and see if the measures thus given for different velocities compare with measures given by other resistances overcome, and for different quantities of heat, electricity, &c., developed by the disappearance of different velocities in the moving mass.

A body, shot vertically upward, with a velocity v, comes to rest, by the opposing resistance of gravity, after having reached a certain height, which we will call h. Giving the body twice the initial velocity, $2v$, it reaches $4h$ before it begins to return to the earth; with the initial velocity $3v$, it reaches the height $9h$; while $4v$ gives $16h$, and so on; in other words, *the heights reached are as the squares of the initial velocities.*

Wherefore, as force = mass × space gone through, it follows that the measure of force is *mass* × v^2; v being the velocity of the mass; or, *force = mass × distance gone through* in overcoming the constant resistance = *mass* × v^2.

If this measure be true, the same ratio of the square of the velocity, will exist when other resistances are opposed to the moving body. Take the resistance offered by an earth or clay bank to the penetration of cannon balls having different velocities. It is found by artillerists, that a ball striking with the velocity $2v$, will penetrate four times as deep as the same ball with velocity v; while a velocity of $3v$ will give a penetration of nine times the depth and so on; the penetration of the same ball being as the squares of its velocities. (See Dr. Wollaston's Bakerian Lecture on the Force of Percussion, Phil. Trans. 1806; and Benton's Ordnance and Gunnery, N. Y., 1862, p. 476, *et seq.*)

Having found this measure of force true for these two cases, where motion disappears, let us determine, as we only can, *experimentally* and *inductively*, whether the relative quantities of *heat* evolved as different velocities of the moving mass disappear, also preserve the ratio of the squares of those velocities.

In the year 1850, there appeared in the Phil. Trans. R. S. Lond., a paper "*On the Mechanical Equivalent of Heat,*" by Dr. James

Prescott Joule, of Manchester, England. This memoir contains one of the most important physical constants ever determined.

In this investigation was first obtained, *by direct experiment*, the exact quantity of heat developed by the falling of a given weight through a known height. His experiments on this subject began in 1843, and were continued during six years, until 1849. Dr. Joule, during this long experimental experience, gradually perfected his apparatus, and learned to eliminate various sources of error, until finally his measures arrived at by different processes gave, within small limits, almost identical values for "the mechanical equivalent of heat."*

His apparatus consisted of an upright copper cylinder, which contained either water, oil, or mercury; in the lid of this vessel were two apertures, one for a vertical axis, to revolve in without touching the lid, the other for the introduction of a thermometer. The vertical axis, which was perfectly fitted into the bottom of the vessel, carried eight revolving arms or paddles, which, as they went round, passed between openings in four stationary vanes, so that the water could not acquire a motion of rotation and move with the arms; and resistance was thus made to their motion. Two weights were attached to fine flexible cords, which passed over pulleys, and were wound round a roller on the vertical axis, armed with the paddles. These weights in falling caused the paddles to revolve, and by the resistance which it opposed to their motion, the liquid was heated by the equivalent in motion expended. The height of the fall was about sixty-three feet (to which we may say that practically the radius of the earth was infinite), and was measured by vertical scales, along which the weights descended.

The mode of experimenting was as follows: the temperature of the liquid having been ascertained by a thermometer, which was capable of indicating a variation of temperature as small as $\frac{1}{200}$th of a degree Fah., and the weights wound up by detaching the roller from the vertical paddle-axis, the precise height of the weights were ascertained after keying the roller; the weights then descended until they reached the floor. The roller was again detached from the

* It is to be remarked that Mayer, in 1842, used the expression "mechanical equivalent of heat," and from the difference in the specific heats of the same weight of air under constant pressure, and under constant volume, theoretically *deduced* a value for this equivalent, which, corrected with the exact data of the above quantities as furnished by Regnault, gives a result nearly identical with Joule's.

paddle-axis, the weights wound up, and the agitation of the liquid renewed. This was repeated twenty times, and then the temperature of the liquid was again observed. The mean temperature of the room was derived from observations made at the beginning, middle, and end of each experiment.

Corrections were now made for the effects of radiation and conduction; and, in the experiments with water, for the quantities of heat absorbed by the copper vessel and by the paddle wheel. In the experiments on the heat produced by the agitation of mercury, and in the heat given out by the rubbing of cast iron plates, the heat capacity of the entire apparatus was ascertained by observing the heating which it produced on a known weight of water in which it was immersed. In all the experiments, corrections were also made for the velocity with which the weights came to the ground, and for the rigidity of the strings. The force expended in friction of the apparatus was diminished as far as possible by the use of friction wheels, and its amount was determined by connecting the pulleys without connection with the paddle-axis, and ascertaining the weight necessary to give them a uniform motion.

The following table gives the results of Joule; the second column, as they were obtained in air, the third, the same corrected, as though the weights had descended in vacuo.

MATERIALS EMPLOYED.	MEAN EQUIV. IN AIR.	MEAN EQUIV. IN VAC.	NO. OF EXP'S FROM WHICH DERIVED.
Water..................................	773·640	772·692	40
Mercury..................................	775·032	774·083	50
Cast Iron..............................	775·938	774·987	20

In the experiments of producing heat by the rotation of one cast iron plate on another, the friction produced considerable vibration in the frame work of the apparatus, and a loud sound; allowance was therefore made for the quantity of force expended in producing these effects.

The number 772·692, obtained as the mean of forty experiments on the friction of water, Joule considered the most trustworthy; but this he reduced to 772, because, even in the friction of liquids,

he found it impossible entirely to avoid vibration and sound. The deductions of Joule from these experiments are :

1. *That the quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the force expended.*

2. *That the quantity of heat capable of increasing the temperature of one pound of water (weighed in vacuo, and between* 55° *and* 60°) *by* 1° *Fah., requires for its evolution the expenditure of a mechanical force represented by the fall of* 1 *pound through* 772 *feet, or* 772 *foot-pounds.*

This is the "*Mechanical Equivalent of Heat,*" or the unit of heat, generally called in honor of the illustrious physicist, "Joule's Unit."

In French measures, the above heat-unit is thus stated: *The heat capable of increasing the temperature of* 1 *kilogramme of water* 1° *C., is equivalent to a force represented by the fall of* 423·55 *kilogrammes, through the space of* 1 *mètre.* The descent or ascent of 1 pound through 1 foot is called *a foot-pound,* while the descent or ascent of 1 kilogramme through 1 mètre is denominated a *kilogramme-mètre.* By the adoption of these terms, the expressions of the above truths can be mere concisely enunciated; thus, using French measures, we say, 423 *kilogramme-mètres is equivalent to* 1 *kilogramme-degree centigrade.*

Thus, Joule showed that the heat developed was in proportion to the mass × the distance fallen through; or, what is the same, equivalent to the mass × square of the velocity.

In a remarkably interesting paper, "*On the Production of Thermo-Electric Currents by Percussion,*" Prof. O. N. Rood, of Columbia College, N. Y., shows directly by careful and skilful experiments, that the heat and its equivalent in dynamic electricity (which latter gave the measure of the heat), produced by a weight falling from different heights on a compound plate of German silver and iron, was in proportion to the height of the fall of the weight, or, what is the same, to the square of the velocity of impact.

For the details of these experiments, and the precautions taken to avoid the action of extraneous causes mingling themselves with the main effect, the reader is referred to Prof Rood's paper in "The American Journal of Science, July, 1866."

We here only give some of the results, which speak for themselves.

TABLE 2.—WITH TWO SKINS ABOVE AND BELOW JUNCTION OF METALS.				
Distances fallen by Weight	1 in.	2 ins.	3 ins.	4 ins.
Deflection of Galvanometer-needles —Average of eight Observations	1°·3	2°·7	3°·55	5·°2

TABLE 3.—WITH FOUR LAYERS OF PLAIN SILK ABOVE AND BELOW THE JUNCTURE.				
Distances Fallen	1 in.	2 ins.	3 ins.	4 ins.
Average Deviation of eight exp'ts.	1°·5	3°·0	4°·5	6°·0

TABLE 5.—WITH FOUR LAYERS OF WAX-COATED WOVEN SILK.					
Distances Fallen	1 in.	2 ins.	3 ins.	4 ins.	5 ins.
Reduced Average Deviation of Five Experiments	1°·07	2°·1	3°·28	4°·3	6°·0

For a proper interpretation of the above results, it is to be remarked that the deflection of the galvanometer needles up to 6° was in proportion to the intensity of the current, which is itself, within these limits, proportional to the heat at the juncture which developed it.

It can be further shown that the measure of force, or *energy* (a term now more generally used, and which we owe to Dr. Thomas Young), is proportional to the square of the velocity of a moving mass, by obtaining the equivalents of effects other than those of resistance offered by gravity, by penetrable bodies, and of the heat developed by friction and by impact. Joule, in 1843, showed that the same relation existed between the heat evolved by the electric current of an electro-magnetic engine, and the mechanical energy expended in producing it, and in 1844 he showed that the heat absorbed and evolved by the rarefaction and condensation of air, is proportional to the amount of mechanical energy evolved and absorbed in these operations.

In the following table, taken from Verdet's "*Exposé de la Théorie Méchanique de la Chaleur,*" *Paris,* 1863, are given the most reliable determinations of the mechanical equivalent of heat. The numbers represent the number of kilogramme-mêtres, which is equivalent to one kilogramme-degree centigrade of water.

NATURE OF THE PHENOMENON WHENCE THE DETERMINATION IS DRAWN.	PHILOSOPHERS WHO HAVE INVENTED THE THEORETICAL PRINCIPLES OF THE DETERMINATION.	PHILOSOPHERS WHO HAVE SUPPLIED THE EXPERIMENTAL DATA.	MECHANICAL EQUIVALENT.
General Properties of Air........	Mayer Clausius	V. Regnault, Moll & Van Beek	426
		Joule	424
Friction..................................	Joule	Favre	413
Work done by the Steam Engine	Clausius	Hirn	413
Heat evolved by Induced Currents	Joule	Joule	452
Heat evolved by an Electro-Magnetic Engine at Rest and in Motion........................	Favre	Favre	443
Total Heat evolved in the circuit of a Daniell's Battery...	Bosscha	W. Weber Joule	420
Heat evolved in a metallic wire through which an electric current is passing................	Clausius	Quintus Icilius	400

From the above discussion, we conclude that the true measure of force is *mass* $\times v^2$.

(To be continued.)

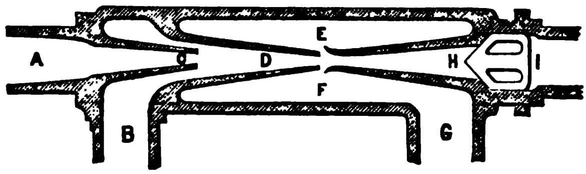
THE PROPOSED PORTLAND AND RUTLAND RAILROAD.—A company has been formed to build a railway, which shall establish direct railway communication with Portland and Ogdensburg, which is situated at the head of lake navigation.

THE GIFFARD INJECTOR.

The Giffard Injector, as all know, is an instrument in which a jet of steam coming out of a boiler, and being condensed by a stream of water, surrounding and mingling with it, imparts to that water such force or velocity that it is able to enter the water space of the same boiler, notwithstanding the resistance of its internal pressure.

In its simplest form, it consists of the following parts, shown in the accompanying cut. A nozzle, A, by which steam is admitted in the axis of the apparatus; around this an annular space by which water from B, flows in around the steam, and mingling with and con-

Fig. 1.



densing it in the conical tube, D, is driven through the pipe, H, and valve, I, into the boiler. Excess of steam or water from want of adjustment escaping by the outlet, F F, and G.*

The action of this instrument seems at first sight, to be discordant with certain principles which are, with good reason, accepted as absolutely certain; and for this cause the mind in grasping the idea of its operation, is disturbed by a sense of this discord, and the difficulty of a clear comprehension, is thus enhanced.

We may therefore well begin our general description by showing how this apparent discord comes simply from a neglect, or omission from our view, of certain important conditions.

At the outset, then, the idea that a jet of steam escaping from a boiler, should be able to enter the same boiler again, carrying with it an added quantity of water, seems to be in direct opposition to the general maxim, that the amount of a force can in no way be increased by the intervention of any sort of machinery.

The following consideration, however, will to some extent, at least, relieve this difficulty. If we suppose the reservoir of steam in the boiler to receive no addition of force or supply during the experiment, it is clear that its elastic force or effective pressure, will

* This cut shows simply the principle of the instrument, all details of construction being intentionally omitted.

be reduced in proportion to the volume of steam withdrawn. Thus if half its contents are removed, the pressure, exerted by what remains, will be reduced to half. On the other hand, if water, even at the full temperature of that in the boiler, is introduced, it will only increase the pressure in proportion to its volume. To restore the pressure of the boiler, diminished by withdrawing half its capacity of steam, the same amount, or half its capacity of hot water must be forced in. Now, in the case of the injector, we know that nothing like this occurs. The steam escapes *as steam*, and is returned *as water*, with a volume reduced say 1000 times, and even if it carries with it twenty times its volume or weight of fresh water, there would still be a loss of pressure or effective force in the boiler, fully equivalent to the work performed in introducing the supply.

The force implied in expelling the steam, and therefore lost by the boiler, would thus clearly be a greater one than that restored by the introduction of the water.

We have, as it were, a rod or cylinder of steam, say 1000 feet long, expelled with a given force or pressure from the boiler, and then by concentrating the force involved in this moving mass, we introduce against the same pressure a rod or cylinder of water, say twenty feet in length.

Clearly, this does not imply any self production or increase of force, but simply the concentration of an extended or diffused power, into a condensed effect. As when a ship is pushed through the water by the action of the wind upon her sails, or a heavy weight is raised a short distance through the intervention of any mechanical power, by the descent of a light weight through a great space. In short, steam pressure being well up in a boiler, if we damped the fire and started the injector, we should soon run down the pressure to a point so low, as to stop the action of the instrument, and this quite independently of the lower temperature of the injected water.

So far for the general abstract principle, and the facts that show us how entirely this apparatus is clear of all relationship to perpetual motion, or self generating force. We will next consider more in detail the special mode of action exhibited in this instrument.

The first point to be apprehended, is the difference between motion and pressure. Pressure is an isolated unit of force; motion, expressed by velocity, is the sum of many of these units.

Where a pressure exists without motion, some force, instant by instant, is in action, but each instant its previous effort is counter-

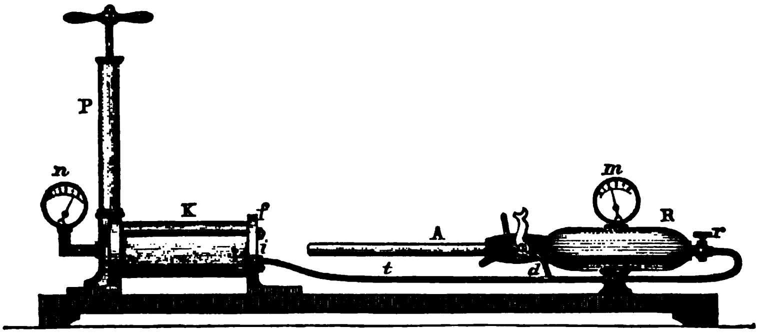
acted and destroyed, by whatever obstacle or resistance prevents motion from taking place, and keeps up the state of *mere pressure.* Thus, no more power is at any time present in the bodies concerned, than that unit or single element evolved by the force in a single instant.

When, however, the resistance is wholly or in part removed, then the force produces a certain amount of motion in the body affected, during the first instant, to which it adds in the second and third and so on; the force thus being transformed into motion, and accumulated in that form in the moving body, so developing a constantly increasing velocity, proportional to the time of action or number of force-units involved.

This principle undoubtedly is concerned in the operation of the injector. The escaping steam acquired a high veloeity, which is in no respect reduced by its condensation into water, and only diminished (in proportion to the additional amount of matter set in motion) by the added quantity of water which it takes up and carries with it against the valve, it is thus easily able to open that valve and introduce the water against the mere *pressure* of the boiler.

This principle is very happily illustrated in the apparatus devised by M. E. Bourdon, and constructed by Salleron (as we see from his catalogue), and which is designed to illustrate the relations which exist between velocity and pressure, in solid as well as in fluid bodies.

There is, in this case, arranged a glass reservoir, K, into which air is forced by means of a condensing pump, P, while a gauge, *n*, denotes the amount of pressure thus developed.



In one end of this reservoir is a valve, *s*, opening inwards, and immediately opposite to it an air-gun provided with a reservoir, R,

which receives its charge from K, by the tube, *t*, and therefore will have exactly the same pressure. Having charged both reservoirs, we then close the stop-cock, *r*, and discharging a ball from the air-gun, it will open the valve, *s*, and enter K, against a pressure fully equal to that which developed its own motion. From what we have said before, the reason of this is clear.

The velocity of the ball expresses the sum of all the forces exerted by the air upon it, during the many instants it occupied in passing out of the barrel of the gun; the resistance of the valve is simply the single force of the air pressure, exerted for the instant required to open it.

Again, we may consider the action in another and quite different light. Let us suppose that the steam is issuing with the full velocity due to the pressure, from an orifice of one inch in area. In the nozzle of the injector it is condensed into water, without, however, suffering any change in its velocity from this cause, its bulk will by this means be reduced, say, 1000 times, and therefore its area of cross section (the velocity being constant), will experience a similar reduction. Neglecting loss by friction, it would then be able to enter the boiler again by an orifice $\frac{1}{1000}$th of that by which it escaped, and we should thus have the total force expended by the steam within the boiler on the area of an inch in expelling the steam jet, concentrated upon the area of $\frac{1}{1000}$th of an inch, and therefore greatly superior to the opposing pressure exerted upon that small area.

If an additional quantity of water were taken up by the jet, as in the actual case of the injector, its velocity would be diminished in an equal proportion, and the area of inlet required for its passage increased in like amount, to make up for its slower motion, and again in equal proportion by reason of the greater volume to be introduced, but we clearly have margin enough for both these deductions. Thus suppose twenty times the weight of the steam added to it in fresh water, thus reducing its velocity to $\frac{1}{20}$th, and demanding an area of inlet increase twenty times to allow for this slower motion, and twenty times again for increased material, in place of 1000 to 1, we should have the areas of escape and entrance, or the power and resistance as 1000 to 20×20, or 400, or as $2\frac{1}{2}$ to 1, which shows an abundant margin for loss by friction, &c.

It may occur to some, that this reasoning looks like a contradiction to the doctrine of hydrostatic equilibrium between large and

[illegible]

[illegible] a high temperature in the feed water, the condensation [illegible] the instrument would not work; while a temperature [illegible] would diminish proportionally the amount of water [illegible]. Such [illegible] as has been observed in practice.

(To be continued.)

COAL AND FIRE-CLAY MINES have recently been opened in Warren County [illegible]. The [illegible] from Warren [illegible] New York [illegible] and a point on the New York and Erie Railroad [illegible] of the Genesee Valley Canal. The [illegible] Herald says: "The exploration has already made discoveries [illegible] the fact that the bed of cannel coal in this mine is four feet in thickness, the bed of fire-clay below it seven feet in thickness, and [illegible] a bed of bituminous coal four feet thick, which will make a draft in the mine of fifteen feet. The quality of the fire-clay is very superior, equal to that of the Pittsburg region, while the coal is pronounced by competent judges, equal to the English cannel brought to the New York market. The proximity of this coal field to the projected railroad from Warren to the Erie road, adds to the marketable value."

COPERNICUS BY EARTHLIGHT.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

Lecture delivered at the Academy of Music, before the Franklin Institute, on May 28d and June 6th, 1868.

BY PROF. HENRY MORTON, PH.D

(NOTE.)—The following report of this lecture has been prepared at the request members of the Institute, and with the view of placing in an accessible form ach matter of general interest in connection with the wonderful developments modern astronomical research (especially those relating to photography and e spectroscope), which are either quite inaccessible to the public at large, or ly to be reached with great labor and cost. In pursuance of this plan, arrangents have been made for the introduction of an entirely new and most valuable ies of illustrations, including fac-similes of the admirable photographs of the oon, made by Prof. Henry Draper, M. D., and Mr. L. A. Rutherfurd, the star ectra, studied and mapped by Prof. W. A. Miller and Mr. William Huggins; ws of sun spots by F. Howlett, and views of the planets by Mr. W. Lassell, r. J. N. Lockyer and others.

PHONOGRAPHIC REPORT.

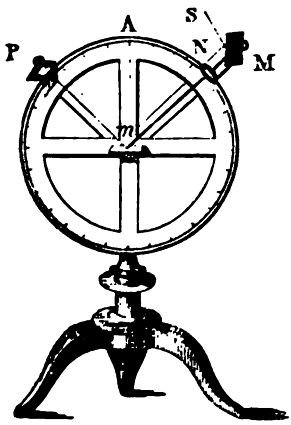
The moon, as we all know, shines by reflecting light, the source which is in the sun. For various reasons, among which it must acknowledged the convenience of our scenic arrangements holds prominent place, we will consider this reflected light and its secondary origin in the first instance, and then follow it back to its fountain and source. This order, however, is not unnatural, and might have been selected even if not suggested by the conditions above mentioned.

Moonlight, then, being reflected light, we will first consider some of the general laws of reflection. At the very outset, however, we must notice that there are two sorts of reflection, one known as regular or as specular reflection, which follows very rigid and precise rules, the other diffused or irregular reflection, which is emancipated from these restraints, but has its own special conditions and modes of action.

When rays of light fall upon smooth or polished surfaces, they are in part repelled or thrown off again in such a manner, that the angles made by the approaching and receding rays with the surface

or its normal (*i. e.* line perpendicular to the surface), are equal. This is illustrated by the accompanying cut.

We have here a vertical graduated circle, on which degrees are marked and numbered right and left from the point M. At the centre is a little horizontal mirror. By means of the adjustable mirror, M, a ray of sunlight is caused to pass through the small opening, N, beneath it, and to fall upon the central mirror, its angle with the normal to that reflecting surface being N*n*A. If now we move the small screen P to such a point that the angle P*n*N is equal to N*n*A, then the reflected ray will strike it, and make a bright spot at its centre.



If, however, light falls upon an irregular or unpolished surface, it is in part reflected, not in any one, but in every direction, and this not from any inversion or abrogation of the other law, but simply from a new condition of its action, as the surface in this case consists of an indefinite number of minute surfaces at every imaginable angle to the incident rays which therefore *ought* to be scattered in every direction, according to the first law.

Yet this difference is a marked and striking one, and deserves our notice and consideration. It is by reason of this difference that a sheet of paper looks bright, no matter how the light falls upon it, while a polished plate of silver or a mirror will seem black unless in a certain position with reference to our eyes and the source of light.

To make this difference clear, and to give impressiveness to the fact, I have arranged some experiments which I will first exhibit to you, and afterwards explain, that you may first enjoy the pleasure of a mystery and a surprise, and then the greater delight of investigation and acquired knowledge as to cause and effect.

You have, of course, observed behind me, this large mirror (for which we have to thank the kindness of Mr. Earle, in whose establishment it was produced), and which has been presenting to you another vast audience, vibrating with the flutter of fans and bright with fair faces. I bring this lighted candle near it, and you see the twin image of its tiny flame, proving if proof be needed, that what is before you is a veritable and vast reflecting surface.

Now I tell you, that there is beside upon that mirror a beautiful fairy or phantom form, invisible to you, equally invisible to me, but able to reveal itself, if we but grant to its bashfulness, or to the magic spell of optical laws to which it is subject, the protection of this delicate white veil, which, as you see, is itself void of any marking or irregularity in its filmy surface. My friend, Mr. Moody, will now place himself on the platform behind the mirror, and will then drop the veil over the surface of the glass.

(A thin veil of bobinet with a rich fringe, and attached to a light rod by means of which it could be pressed close to the surface of the glass within the frame, was here let fall over the mirror, when at once a beautiful figure of Ariel appeared as if on the veil.)

Instantly the Phantom of the mirror and veil, the Spirit of reflected light, appears in delicate beauty. The veil is now wrapped together and drawn off to one side, seeming to enfold and shroud the Spirit within, and both fall together to the floor, from which I now raise the veil, empty of its celestial visitant, as at first.

Let us now look for an explanation of these results. That little box with its brazen nose, is the "magic lantern," or "Aladdin's lamp," to which this spirit owes obedience.

Shut up within its thin walls, has been burning since the curtain rose, a brilliant lime light, whose rays, collected and guided by various lenses, have been all along and are now projecting a fairy-like image upon the surface of the mirror, but the rays which form this image, coming obliquely from one side, are thrown off obliquely toward the other, and are lost behind the side scenes.

When the veil descends over the glass, it offers a surface capable of irregular reflection, and the rays no longer following a single path, are scattered in all directions, so that some from each point reach the eyes of every one, no matter where he may be placed in the house.

We will now change the arrangement of the mirror somewhat, so that the reflected rays will no longer fall behind the scenes, but upon this transparent screen, which is supported close to the edge of the stage on the opposite side to that occupied by the lantern. You then see the phantom figure, on a larger scale, clearly depicted on this screen, while yet as before, no sign of an image is visible on the mirror, although as you know, it is only by way of, and through reflection from, this mirror that any image reaches the

screen at all. If a small screen of white paper is held over part of the mirror, an image is clearly seen upon it, while the corresponding portions of the figure disappear from the transparent screen in front.

We now remove the picture from the lantern, and allow a broad sheet of light to fall upon the mirror, and to be reflected to the transparent screen, brightly illuminating it.

I now breathe upon the mirror, and at once you see a bright spot on the glass, and a dark one on the screen. The fine particles of moisture give an irregular surface on the glass, which scatters the light in all directions, so that some of it enters the eyes of each one, but for that very reason but little goes to the screen.

Again, I take this little steam atomizer, which is projecting a misty spray of water, and with its jet as a brush, trace on the surface of the mirror, characters which *there* seem drawn with fire, but on the screen appear painted with ink.

This, then, illustrates the difference between regular and scattering or diffusive reflection. To the first we owe those beautiful effects of duplicated images we see in still water, presenting an inverted image of every object in its vicinity, as well as the countless uses and applications to which mirrors and polished surfaces are applied.

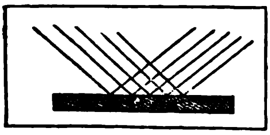
To the second, we owe the visibility of all ordinary objects which are seen by the scattered light they reflect, and among which the moon is to be classed in this relation. Of these various effects, I now bring before you many beautiful illustrations in the pictures which are being projected on the huge screen, forty feet square, which, while I have been speaking, has silently descended just behind me, and on which, Mr. O. H. Willard, well known to many of you for his skill as a photographer, is projecting from a large lantern, 90 feet back at the rear of the stage, various admirable photographs of his own production, prepared specially for their present use, and representing, as you see, landscapes with still water, in which the shrubs, and trees, and buildings on the banks, find themselves reflected, and pictures in which groups of statuary and other objects are combined with mirrors, in such a way as to illustrate the various points to which we have alluded.* (A number of pic-

* The lantern used on this occasion was the large one made by Mr. J. Zentmayer, and described in this *Journal* at page 280, Vol. LIV., having a triple lens condenser eight inches in diameter, and supplied with photographic glass pictures of a corresponding size. With a large jet, burning about four cubic feet an hour of each gas, this lantern covers the immense screen of 1600 square feet, in a most satisfactory manner.

tures were here exhibited and described, which it would be impossible for us to reproduce in this place without an outlay incommensurate with their actual importance, we must therefore leave to the reader's memory of actual scenes and his imagination, the details of this subject.)

Before leaving this department of our subject, we may well devote a little time to the more full expression of the results flowing directly from the law of regularly reflected light already stated. In consequence of the equality between the angles of incident and reflected rays, it follows that the mutual relations of a group or sheaf of rays will not be changed by reflection, though their common direction will be altered. Parallel rays will remain parallel, and diverging rays will diverge exactly as before. This is shown by figures 2 and 3, which explain themselves.

Moreover, we see that if diverging rays are reflected by a plain surface, their paths after this action will be exactly such as they would have followed had they come from a point exactly as far *behind* the reflecting surface, as their real origin is in front of it, and in a like relative position.



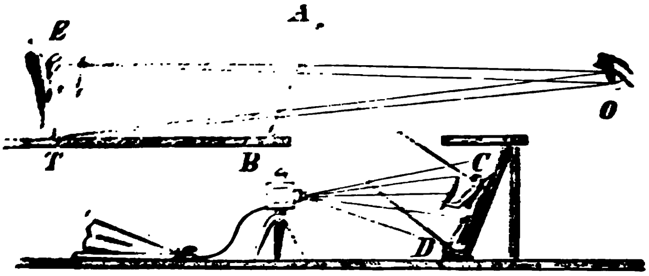
This is shown in Fig. 3, where the rays from A, after reflection, pass off exactly in the same paths they would have followed if emanating from B. An eye placed at C would, therefore, receive them exactly as if they had come from B, and if unaware of the reflecting surface, would believe them so to originate.

It is thus that all objects seen in a mirror appear to be behind its surface, and would actually deceive us, did we not, from experience, correct the impression.

Advantage is taken of this in many ingenious optical deceptions, which have been devised of late years, such as the Ghost, invented by Dr. Pepper, of London, the Floating Head, the Sphinx and the Proteus. I do not attempt to show you any of these, because the existing conditions of size and arrangement in this house, unfit it for such a purpose. But I will briefly describe one of them, which will illustrate the facts just mentioned, and the principle involved in all these devices.

The Ghost is thus arranged. A large sheet of unsilvered plate glass is placed across the stage, near the front, as at AB., care being

[illegible] and arrange-
[illegible] A figure
[illegible] is placed at CD, be-
[illegible] a lime light.



The rays of diffused light from this figure, passing through the trap door above it, are reflected from the glass into the eyes of the audience at O, precisely as if they came from an object situated at ET, and the presence of the reflector being unknown, the deception is very perfect.

The various points above noticed show us that the kind of reflection by reason of which the moon shines, is diffused, and not regular, for if the moon were a polished ball, she would shine but as a single point or star of light, as does any smaller polished ball or bead; and even if (disregarding all astronomical fact) we assumed the moon to be a vast flat polished disk, it could only then show us an image of the sun, which would be entirely lost by a very slight change in our relative positions.

The moon, then, must possess an irregular surface, which scatters the light rays of the sun falling upon it, in all directions, so that we receive some of them whenever we are anywhere within sight of her illuminated face. Like the light similarly reflected from other familiar objects, this will, therefore, by its changes, differences, and irregularities, reveal to us the character of the body by which it is thrown off, and in this way we shall now use it in a study of the moon's topography, structure and scenery.*

* The frontispiece of this article, representing the Lunar Volcano, Copernicus, and its vicinity, as seen by earth light, which will be more fully mentioned in future, is engraved from one of the admirable drawings made by Mr. James Hamilton, to illustrate this lecture by the use of photographs taken from them, and projected on the screen.

(To be continued.)

CHEMICAL EXPERIMENTS FOR THE LECTURE-TABLE.

By Prof. Albert R. Leeds.

(Concluded from page 420.)

Ignition of Sulphur and Phosphorus in an atmosphere of Oxygen.—Through the cork of the apparatus, figured on page 319 of the second American edition of Graham's Elements of Inorganic Chemistry, to illustrate the continued manufacture of phosphoric acid, and which may likewise serve for the formation of sulphurous acid by direct combustion, two copper wires are passed at diametrically opposite points. The lower ends of these copper wires are connected by fine platinum wire, three-quarters of an inch in length. The wires are then forced down into the bottom of the porcelain crucible, and the platinum covered with pieces of phosphorus or sulphur. The outer ends of the copper wires are connected with the poles of a galvanic battery, consisting of two Bunsen cells. The brilliant flash of light which ensues upon making a connection with the battery, standing perhaps many feet off, is of a striking description. An attempt was made to start the combustion of iron wire in oxygen, in a similar manner, by connecting the ends of two iron wires by a piece of platinum wire, a quarter of an inch in length; but, although the connecting wire became incandescent, the iron did not ignite. It may be that a stout piece of platinum and a large battery would succeed, but the employment of a greater number of cells than two was not thought worth while.

New forms of Aspirators.—On page 49, July number, 1867, of the *Journal of the Franklin Institute* will be found a drawing of a large glass tank for exhibition of chemical experiments. One of the two lateral reservoirs figured in the engraving, will be found a very convenient aspirator for drawing oxygen through the globe spoken of above, as being employed to illustrate the continued manufacture of phosphoric acid, or for similar experiments. The construction of the aspirator is as follows: Close to the bottom of a japanned tin pail, which is ten inches in depth and eight inches in diameter, a brass stop-cock is fastened and allows the water to run off into a bucket placed on the floor. The tube of the stop-cock, which is somewhat longer than usual, has a short, vertical tube fastened into its upper surface, in front of the stop-cock. This vertical tube is connected by means of an India-rubber tube, with the

wash bottle or other vessel, through which air is to be drawn. On partially opening the cock, the deficiency of water in the pipe leading to the bucket is supplied by a continued current of air drawn in through the vertical tube.

A still simpler contrivance, when there is, as there should be, a hydrant-cock at the back of the lecture-table, is to attach a two-way tube, made in the form of a Y, to the hydrant. The wide upward arm carries off the stream of water, and the air is drawn in a rapid current through the narrow arm.

The gasometer, which is figured and explained in another part of this number of the *Journal*, serves also as an aspirator for small but regular amounts of gas, and has the further advantage that no water besides that which is contained in the apparatus is required.

Cell for exhibiting Electrolysis upon the Screen.—A glass tank, similar to that above mentioned, as described by Prof. Morton, in the October number, page 281 of the *Journal*, may be employed for the following experiments also. The two upper clamps, however, contain in addition a screw passed through the end faces of the front corners of the clamps, as seen in the drawing, and serve for the adjustment and fixing of the two copper wires which form the poles of the battery. These wires are connected below the two upper clamps by means of binding-screws with the battery, and rising to the height of two or more inches above the cell, curve downward so as to form an inverted U, and terminate in strips of platinum foil the one-eighth of an inch wide, and two inches in length. The electrodes are separated by a thin partition of India-rubber, which terminates about the three-eighths of an inch above the bottom of the cell, and thus allows a free passage to the galvanic current, without any admixture at the same time of the anion and cathion. It is best to make the tank quite small—three inches square is sufficient—and to employ an inverting prism in the lantern used to project the decompositions on the screen. In this way, the audience will obtain a clear idea of what otherwise appears from its complicated look as seen upon the screen, quite difficult of comprehension. When a dilute solution of potassic iodide and starch is introduced in the tank, and a connection is made with the battery, a dark blue cloud at once encircles the electro-positive pole. Every time the connection is made or broken, the slight jar imparted to the electrode sends off a fresh wavelet of starch iodide into the sur-

rounding colorless fluid, until finally, one-half of the screen becomes invisible, the other half remaining cloudless. On reversing the electrodes, the whole tank becomes opaque.

When the tank contains a neutral solution of potassic or sodic sulphate, the change of a solution of litmus from purple to red at the anode, or of one of violets or red cabbage to red at the anode, and green at the cathode, or of cochineal to yellow at the anode, and purple at the cathode, may be shown. The last experiment is not very satisfactory, on account of the slight alteration of tint.

If the electrolytic cell contains brine, the bleaching action of the chlorine, which is liberated at the electro-positive pole, upon litmus, ink, magenta, cochineal, &c., may be shown. It seems very singular, that while an ink (the one employed was made of logwood and bichromate of potash) may be bleached to such an extent as to allow the light to pass freely through the electro-positive side of the decomposing cell, a deeply colored solution of litmus will not, and this too though the electro-negative side of the tank, to one looking directly at it, appears purple, and the electro-positive side colorless. The reason is to be found in the great number of particles of bleached organic matter which float about in the liquid, and render it turbid. A similar difficulty is encountered from the opacity produced by the froth, which is formed by the escaping bubbles of gas.

Improvement in the Construction of the Magic Lantern.—On page 132, August number, 1867, of the *Journal*, will be found a drawing of the Magic Lantern, in the greatly improved form employed by Prof. Morton, and on page 133 a description of the apparatus for carrying the lenses, as follows: "The lenses, &c., may be attached by means of brass tubes, to the cell of this condenser; but where it is desired to adapt the lantern to a great variety of uses, such as will be described in these papers, it is far better, or rather essential to have a separate support for the objectives, with a free space for insertion, arrangement and removal of 'objects' between. For this purpose, the most convenient and 'flexible' (we use the word in a figurative, not literal sense) arrangement, is that shown in the cut. A flat strip of black walnut, mahogany, or cherry, is attached to the front of the box, as shown at E L, and upon it slides an upright frame, M N, into the grooves of which drop pieces provided with rings like I, fitting the various instruments to be employed." I

have somewhat modified the above construction, and I believe that Prof. Morton thinks to advantage, by fastening the upright, which carries the cells for the lenses, permanently to the flat strip of wood, and making the latter move in and out to the extent of twelve inches, between wooden grooves fastened to the bottom of the lantern box. This gives such firmness to the lantern that it is independent of the table upon which it is placed for support, and it may be tilted at every angle without any fear of displacement of parts from the weight of the brass cell of the objectives, &c. When not in use, the lenses may be pushed back against the front of the lantern, so as to occupy the least possible space, and when required they may be drawn at once into position.

Drafting and Writing upon the Screen.—It is often desirable to write out chemical formulæ, or to perform some simple numerical calculation, or to make a diagram of some apparatus, before an audience in a large room. This, which would be difficult of accomplishment by ordinary methods, may be satisfactorily performed in the following manner. A sheet of clean glass, or what is more striking in appearance, a plate covered with an opaque film of blackened collodion, is placed in front of the condenser, and then the writing or drawing is executed upon it: in the former case, with India-ink, in the latter, with a sharp point. An inverting prism placed in front of the objective brings the writing into its natural position with respect to top and bottom, and the inversion of the picture with respect to right to left, instead of being in this case a disadvantage, effects the very object in view. For the writing which is executed by the lecturer while facing his audience, is itself inverted with respect to a lantern facing in an opposite direction.

Transpiration of Gases.—On page 14, of *The Student's Practical Chemistry*, will be found a description of the apparatus which is usually employed to illustrate the transpiration of gases through porous partitions. If, instead of employing a straight glass tube to dip down into the vessel filled with colored liquid, one is employed which has been bent into three or more spirals at different parts of its course, so as to cause the liquid to run round upon itself many times in its upward course through the tube, the experiment takes a much more pleasing and striking appearance.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, May 30th, 1868.

THE meeting was called to order, with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the library received at their stated meeting, held May 13th inst., from the Royal Astronomical Society, the Chemical Society, the Society of Arts, and William Leighton Jordan, F. R. G. S., London; l'Academie des Sciences, la Société d'Encouragement pour l'Industrie Nationale, Paris, la Société Industrielle, Mulhouse, France; der K. K. Geologischen Reichsanstalt, Vienna, Austria; Major L. A. Huguet-Latour, Montreal, Canada; Commodore B. F. Sands, Superintendent U. S. Naval Observatory, Washington, D. C.; James B. Francis, Esq., Lowell, C. L. McAlpine, Esq., C. E., Stockbridge, and E. H. Derby, Esq., Boston, Mass.; Young Men's Association, Buffalo, N. Y.; John Alexander Ferris, Esq., San Francisco, California; and George E. Chambers, Esq., Registrar of Board of Health of Philadelphia.

The various Standing Committees reported their minutes.

A paper upon "Pneumatic Bridge Foundations," by Mr. O. Chanute, was read by the Secretary.

The Secretary's Report on Novelties in Science and the Mechanic Arts was then read.

After which, on motion, the meeting adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notices.

Catalogue of Philosophical Apparatus. E. S. Ritchie & Sons. Boston, 1868.

We have just received the above, which is a new edition of Mr. Ritchie's well known illustrated Catalogue, which, as many of our readers know, is the most extensive and best executed work of the kind ever produced in this country.

The present edition is worthy of special note, by reasons of several additions which have been made, and certain alterations introduced to keep pace with late discoveries, and inventions in the direction of physics.

A few of these novelties we will here notice. Thus, on p. 4, is shown a very neat and compact arrangement for the illustration of pulleys, the capstan, &c., possessing many advantages over that heretofore in use. On p. 11, an exceedingly well arranged and substantial hydraulic press. On pages 13 and 15, is figured (entire and in detail), Mr. Ritchie's new air-pump, described in this *Journal*, p. 13, of the present number. On p. 21, is shown Edson's Hygrodeik, fully described in this *Journal*, Vol. LV., p. 67. On p. 26, an improved form of Natterer's apparatus for liquefying gases. On p. 27, Mr. Ritchie's improved form of the Holtz Machine, described in this *Journal*, Vol. LIII., p. 344. On p. 34, Mr. Ritchie's Liquid Compass, fully described in this *Journal*, Vol. LV., p. 218. On p. 41, a large number of Geissler's Tubes, which Mr. Ritchie is the first to manufacture in this country, and thus puts within reach of all, these most beautiful of modern instruments, without the risks and annoyances attending importation. On p. 42, we find Prof. Lyman's apparatus for the illustration of wave motions, a full account of which will be published in our next issue. On p. 48, we find various new apparatus devised by Kœnig, to illustrate musical vibrations by means of the images of flames (controlled by the vibrating body), in revolving mirrors. On p. 54, account is given of magic lanterns, with many of the accessories described in various papers on this subject, which we have published during the last year. There are, beside these, other novelties, which our space is too curtailed to notice, and the entire catalogue will be of great value to all concerned with physical researches or demonstrations.

We have received from J. B. Lippincott & Co., and will notice in our next issue, *The Mechanics' Tool-Book.* By W. B. Harrison. And *The Practical Use of the Blow-Pipe.* By G. W. Plympton, A. M., both published by D. Van Nostrand, New York.

A COMPARISON *of some of the Meteorological Phenomena of* MAY, 1868, *with those of* MAY 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	May, 1868.	May, 1867.	May, for 17 years.
Thermometer—Highest—degree	77·00°	87·00°	90·00°
" date	30th.	29th.	7, '60; 23, '63
Warmest day—mean	68·00	78·67	79·83
" " date	30th.	29th.	23d, '63.
Lowest—degree	40 00	36·00	35·00
" date	3d & 8th.	4th.	7th, '54.
Coldest day—mean	48·83	43·17	40·00
" " date	8th.	3d.	3d, '61.
Mean daily oscillation	14·80	17·64	16·85
" " range	4·65	5·30	5·51
Means at 7 A. M.	54·32	54·10	58·02
" 2 P. M.	63·50	64·02	69·06
" 9 P. M.	57·19	56·50	60·93
" for the month	58·34	58·58	62·67
Barometer—Highest—inches	30·209	30·423	30·423
" date	12th.	4th.	4th, '67.
Greatest mean daily pressure	30·195	30·367	30·367
" " " date	11th.	4th.	4th, '67.
Lowest—inches	29·375	28·778	28·778
" date	7th.	8th.	8th, '67.
Least mean daily pressure	29·492	29·013	29·013
" " " date	7th.	8th.	8th, '67.
Mean daily range	0·144	0·214	0·128
Means at 7 A. M	29·846	29·855	29·802
" 2 P. M	29·835	29·804	29·766
" 9 P. M	29·841	29·836	29·791
" for the month	29·841	29·832	29·786
Force of Vapor—Greatest—inches	0·592	0·625	0·771
" date	27th.	29th.	14th, '54.
Least—inches	·177	·139	·069
" date	8th.	4th.	2d, '61.
Means at 7 A. M	·338	·310	·352
" 2 P. M	·376	·305	·368
" 9 P. M	·379	·320	·375
" for the month	·364	·312	·365
Relative Humidity—Greatest—per cent	97·0	96·0	100·0
" date	7th.	8th.	Often.
Least—per cent	30·0	29·0	16·0
" date	10th.	2d.	5th, '55.
Means at 7 A. M.	78·7	71·3	71·4
" 2 P. M.	64·1	48·1	51·7
" 9 P. M.	79·7	67·5	69·0
" for the month	74·2	62·3	64·0
Clouds—Number of clear days*	4·	7·	9·5
" cloudy days	27·	24·	21·5
Means of sky covered at 7 A. M	80·3 per ct	62·8 per ct	60·1 per ct
" " " 2 P. M	77·7	67·9	62·5
" " " 9 P. M	61·6	50·0	48 6
" " for the month	73·2	60·2	57·1
Rain—Amount—inches	6·890	7·070	5·071
No. of days on which rain fell	13.	12·	12·5
Prevailing Winds—Times in 1000	N.21°32′E.245	S 82°24′W.099	N76° 6′W. 111

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the* SPRING *of* 1868, *with that of* 1867, *and of the same Season for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	Spring, 1868.	Spring, 1867.	Spring, for 17 years.
Thermometer—Highest—degree	77 00	87·00	90·00
" date	May 30.	May 29.	May 7, '60. 23, '63
Warmest day—mean	68 00	78·67	79·83
" " date	May 30.	May 29.	May 23, '63.
Lowest—degree	6·00	20·00	4·00
" date	Mar. 4.	Mar. 15.	Mar. 10, '56.
Coldest day—mean	10·83	25·67	10·83
" " date	Mar. 3.	Mar. 18.	Mar. 3, '68.
Mean daily oscillation	15·76	16·01	15·95
" " range	6·45	5·62	6·01
Means at 7 A. M.	44·05	45·15	46 61
" 2 P. M.	54·21	55 38	57 71
" 9 P. M.	48·09	48·71	50·39
" for the Spring	48·78	49·75	51·57
Barometer—Highest—inches	30·600	30·485	30·600
" date	Mar. 6.	Mar. 15.	Mar. 6, '68.
Greatest mean daily pressure	30·544	30·450	30·544
" " " date	Mar. 5.	Mar. 15.	Mar. 5, '68.
Lowest—inches	29·115	28·778	28·778
" date	Mar. 2.	May 8.	May 8, '67.
Least mean daily pressure	29·249	29·018	28·959
" " " date	Mar. 2.	May 8.	Ap. 21, '52.
Mean daily range	0·214	0.228	0 167
Means at 7 A. M.	29·974	29 951	29·837
" 2 P. M.	29·945	29·904	29·791
" 9 P. M.	29·954	29·927	29·822
" for the Spring	29·958	29·927	29·817
Force of Vapor—Greatest—inches	0·592	0·625	0·771
" date	May 27.	May 29.	May 14, '54
Least—inches	·042	·060	·023
" date	Mar. 3.	Mar. 29.	Mar. 5, '58.
Means at 7 A. M.	·236	·226	·249
" 2 P. M.	·270	·229	·266
" 9 P. M.	·274	·241	·270
" for the Spring	·260	·232	·262
Relative Humidity—Greatest—per cent.	100·0	96·0	100·0
" date	Mar. 23.	May 8.	Often.
Least—per cent.	30·0	21·0	13·0
" date	Often.	April 6.	Ap. 13, 52.
Means at 7 A. M.	75·7	70·1	71·9
" 2 P. M.	59·7	50·3	52·3
" 9 P. M.	74·8	66·2	68·1
" for the Spring	70·1	62·2	64·1
Clouds—Number of clear days*	17·	23.	27·1
" cloudy days	75·	69·	64·9
Means of sky covered at 7 A. M.	71·5 p. c.	65·3 p. c.	61 5 p. c.
" " " 2 P. M.	67·5	66·6	63·9
" " " 9 P. M.	58·8	51·4	50 0
" " " for the Spring	65·9	61·1	58·5
Rain and melted snow—Amount—inches	15·580	14·100	13·016
No. of days on which rain or snow fell	37·	40·	36·4
Prevailing Winds—Times in 1000	N15°35′W·108	N29°59′W.123	N68°31′W.169

* Sky one-third or less covered at the hours of observation.

// JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] AUGUST, 1868. [No. 2

EDITORIAL.

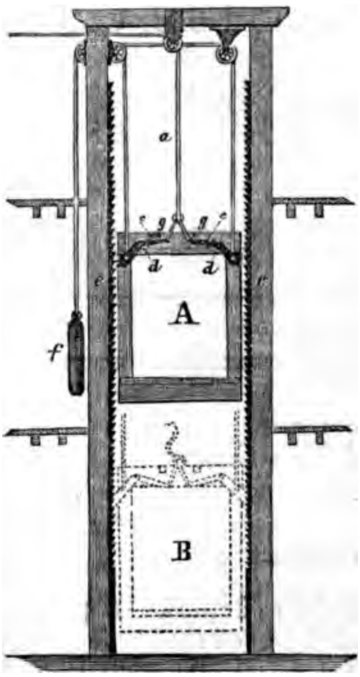
ITEMS AND NOVELTIES.

The Hoosac Tunnel.—Mr. Latrobe's Report.—A possible misconstruction of some remarks, made by us on the above subject in our last issue, having been suggested, we take the earliest opportunity of explaining: that, feeling, as we must, a sincere respect for Mr. Latrobe and his professional ability, it would be the furthest thing possible from our intentions to speak of his opinions with anything but respect, even when we are not ready to support his views in every particular.

If, therefore, any phrase we have used should have an air of irony, it is, in our estimation, equally unfortunate and opposed to our intention. We should, for our own part, never have imagined that any such explanation as the above was needed, but our attention having been called to the subject, we consider it equally due to Mr. Latrobe and ourself to make it.

That a playful accusation of not reading the *Journal*, should be supposed to cast a reflection upon any person or thing but the *Journal* itself, for failing to secure readers, never entered our mind, and, indeed, we sincerely hope that the unfortunate construction, already mentioned, has not occurred to any other than the one of our friends who has suggested it to us.

Safety Hoisting Apparatus, exhibited at the meeting of the Franklin Institute, June, 17th, 1868. In the drawing, A is the hoisting cage or platform on which the load is placed, *cc* are two levers having fulcra at *dd*, and provided at their outer extremities with teeth which take into the racks *ee*, extending the whole height of the hoistway, and attached to vertical timbers provided to receive them, and which, at the same time, serve as guides to the cage.



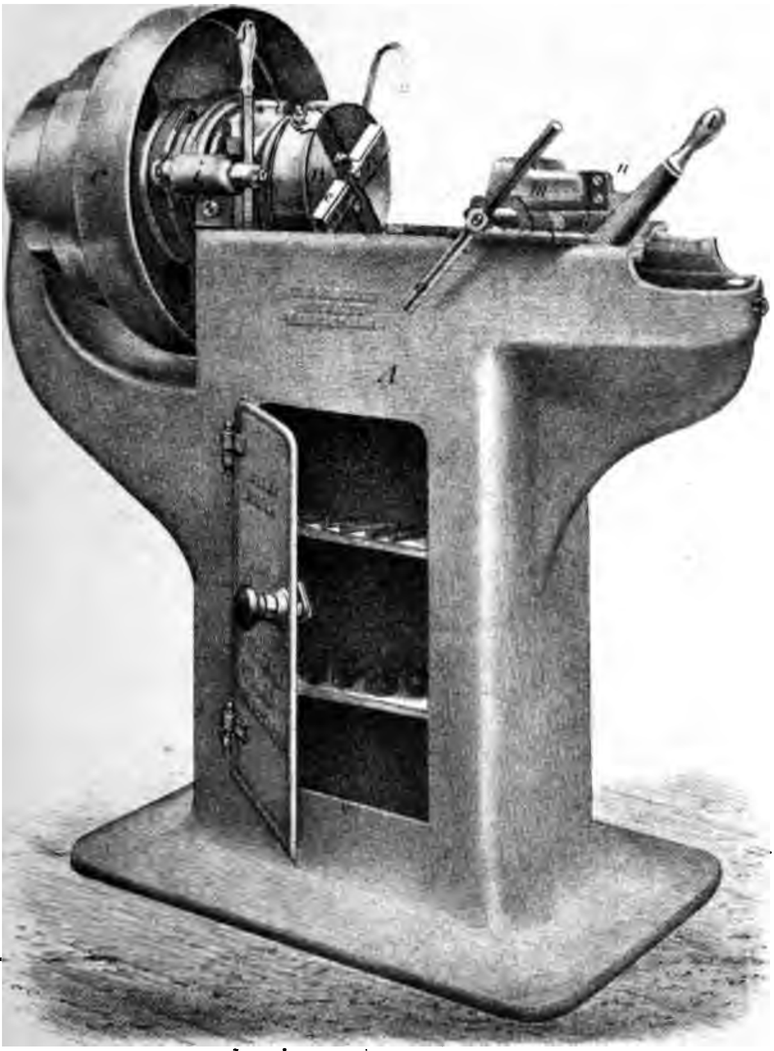
The minor ends of the levers, *c c*, are connected with the main chain or rope, *a*, by which the hoisting is done; to the outer ends of these levers are attached ropes or chains which, passing over leading pullies, are connected with a counterbalance weight, *f*.

The stops, *g g*, are so arranged as to allow the levers, *c c*, sufficient motion to withdraw the teeth from the racks, and to permit the cage to pass freely up and down the hoistway.

Should an accident happen to the hoisting chain, the weight of the cage instantly comes upon the counterbalancing ropes, and the levers being drawn out, the teeth take into the rack and the cage is prevented from falling.

The use of a counterbalance weight is of further service in reducing the work to be done by the hoisting engine. This apparatus is patented by Messrs. Merrick & Sons, of this city.

Some Novelties in Machine Tools.—We lately spent a morning very pleasantly in going over the admirably arranged works of


A

Messrs. Bement & Dougherty, at Twenty-first and Callowhill Streets, in this city. The special object of our visit was an immense vertical boring and turning machine, which had just been completed for the United States Navy Yard at Charlestown, Mass.

Beside this huge mechanical monster, weighing no less than 140,000 pounds, and capable of licking into shape a mass of iron 23½ feet in diameter, we saw and took note of various other processes and things which will be of no little interest to our readers generally.

One of these we shall describe at the present time, and others in subsequent numbers.

We select, as the first, an 1¼-inch opening die bolt cutter, with self-oiling arrangement.

Fig. 1, Plate I., is a cut from a photograph of the machine. Plate II., Fig. 2, is a longitudinal section of the spindle. Fig. 3, a transverse section of the spindle, showing internal gear and segments. Fig. 4, a transverse section of the spindle, showing the reversing spring. Fig. 5, a front view of the spindle. Fig. 6, a view of the spindle head. Fig. 7, a vertical section of the pump.

Similar letters refer to similar parts throughout the several views. A is a hollow cast iron frame with shelves and closet door, provided with suitable bearings for the hollow cast iron spindle, B, on which is secured a cone-pulley, C, in place of which gearing is used for larger machines. A disk, D, with an internal gear in front, and a flange on the outside is fitted snugly on the hub of the cone-pulley, C, but so as to turn freely, its motion being limited by the ends of the segments, E, striking against the spindle, B. In the rear of the disk, D, is a coiled spring, one end of which is fastened to the cone-pulley, and the other end to the disk, D. The segments, E, are keyed on the ends of eccentric steel-spindles, *a a*, which turn in the enlarged part of the spindle, B; the other end of the eccentric spindle works in a slot of the square steel block, *b*, on which is the adjustable die-holder, *c*, the reversible die, *d*, is bolted to the die-holder, *c*. The spindle-head is also provided with two tap-holder jaws, *e*, thus obviating any changing for tapping nuts. When the dies are to be opened the handle, *f*, on the brake, *g*, is moved in a vertical position, thus clamping the flange on the disk, D, by the brakes, *g* and *h*, which slide in a bearing, *i*. The disk, D, being held from revolving, causes the segments, E, to turn, and with them the spindles, *a a*, thus raising the die-holder blocks with the dies. By turning the handle, *f*, back again the coiled spring forces the disk back

again, and with it the segments into the cutting position. The segments are provided with a piece of leather on one end to prevent the noise when being forced back by the spiral springs. The pump, F, is fastened in the reservoir cast for it in the frame. The hollow plunger, *k*, has a small roller on top, and is forced down by an eccentric on the spindle, B, and is held up against it by a spiral spring, thus effecting a reciprocating motion; the oil is strained by a seive, thus allowing it to be used over and over again.

The tapping or sliding-head, G, Fig. 1, is forced up by a lever, *l*, having a pawl connected to it which works in a single rack fastened on the end of the main frame, central between the slides. The weight of the lever will keep the pawl out of the rack, allowing the sliding-head to be drawn back by hand. The nuts to be threaded are held between the sliding jaws, *m* and *n*, Fig. 1, by a right and left-hand screw worked by the spider, *o*.

[We owe the three following items to the kindness of Prof. De Volson Wood:]

The Tunnel at Washington Street, under the Chicago River, is progressing favorably. The old company commenced their work close to the river, and excavated vertically down; but the present company commenced at the ends and are approaching the river both ways. The main tunnel forms a double track passage, and a separate tunnel in the same excavation a passage way for footmen.

A coffer-dam encloses half the width of the river, and an open cut will be made to the centre of the river, and the tunnel built to the end of the excavation and closed.

The water will then be let in and the other half enclosed in a similar way, and the remainder of the cut made and the tunnel completed. It will probably be ready for use next spring W.

Canadian Mining.—There are large mining interests in Canada, which, if properly encouraged by the Government, will doubtless be rapidly developed, and bring much capital and public enterprise into the dominion. A large iron mine, pleasantly located on Lake Marmora, was opened forty or fifty years ago, but was soon abandoned. Last year, a company was formed, composed largely of American stockholders, for working this mine. They shipped their first ore in July, 1867, and this year they are moving several thousand tons. The mine is above the level of the lake, and they are now working 200 to 300 feet from it. The ore is taken on cars from the mine to the river Trent, about eight miles, where it is dumped on barges and shipped twenty-seven miles to the Cobourg

DETAILS
of
Bolt and Nut Threading Machine

BEMENT AND DOUGHERTY
INDUSTRIAL WORKS,
July 1st 1868
Philadelphia.

Fig. VII.

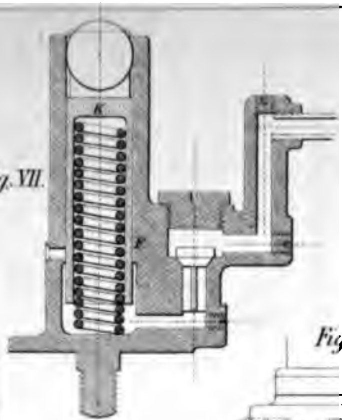


Fig. II.

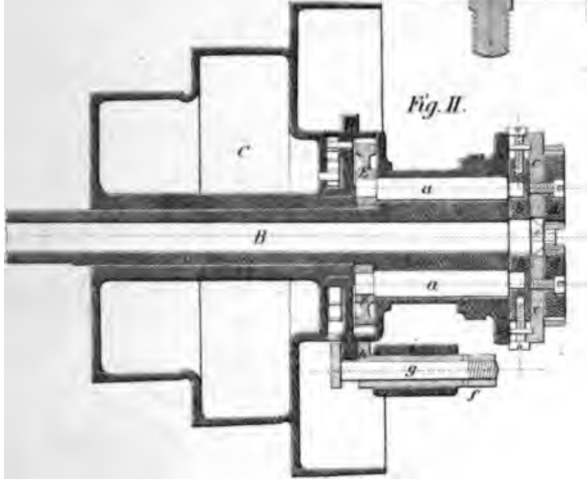


Fig. VI.

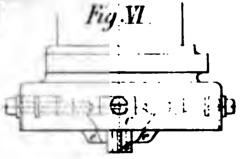


Fig. V.

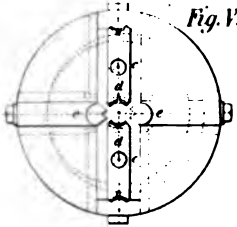


Fig III.

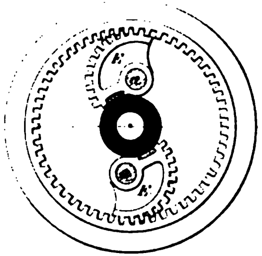
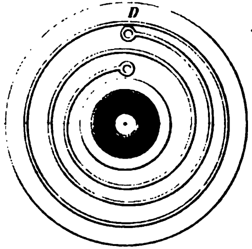


Fig. IV.



Lith. of Mc Gurgan Philada.

and Peterborough railroad; thence it is taken on cars fourteen miles to Cobourg, where it was transferred to sailing vessels and shipped to furnaces in New York and Pennsylvania. The Madoc gold mines are twelve miles east of Lake Marmora. I just saw over forty dollars worth of the metal, which was taken from half a ton of the ore, but practically, they have not succeeded in reducing it at the mine. A gentleman, who claims to be familiar with the business, thinks that the ore is similar to the Colorado ore, and when reduced in the same way as the latter, will yield large profits.

Large iron mines still further east were opened last year with a fair prospect of paying well.

The gold mines of Nova Scotia are generally good. In one district, they produced last year over $1,600 for every male person in the district. W.

Loss of Power in Steam Generators.—Steam has revolutionized many kinds of business during the past thirty years, by cheapening the products of industry, but could we utilize one-fourth the total heat in the fuel used for generating steam, and for domestic purposes, it would produce a greater revolution in the *economy* of business than has yet been witnessed. According to Andrews, one pound of anthracite coal has sufficient heat when burned, to raise 14,220 pounds of water one degree of Fahrenheit's scale, which multiplied by Joulé's equivalent, 772 foot-pounds, gives 10,977,840 foot-pounds. If the pound of coal produced this result in one hour, it would be equivalent to 5½ horse-power.

A good engine will produce a horse-power from four pounds of coal, and the very best from two pounds; thus utilizing 9 per cent. in the latter, and 4½ per cent. in the former. W.

American and English Railway Carriages Compared.—We extract the following from a Buenos Ayrian paper, being part of a letter written by the (English) traffic manager of the Northern Railway of Buenos Ayres:—

"We find also that three American carriages only weigh one ton more than two English make; the three American carriages seating seventy-two passengers more than the two English, against the same amount of dead weight.

"Their expenses of repair amount during the past ten months to $40.866, currency, or $4.086 currency, for each, whilst during the same period, the American carriages have not cost anything for repair, and are at present in better condition than those made in England, although they have been in constant use since the line

was first opened. I may also remark that their chilled iron wheels scarcely show any perceptible wear.

"The American carriages are in every respect a better and more comfortable carriage, requiring less than one-half the power to propel them that is necessary for the carriages of English construction. It has also been proved that the English carriages are much more injurious to the permanent way and works, and likewise, in proportion, more destructive to themselves than those of American construction." (Signed) J. Boyd Thomson,

of Glasgow, Managing Agent. B. A.

Direct Acting Circular Saw Mills.—Of late years, fast running engines for operating lumber mills, have obtained firm footing in the west. Small cylinders, with short stroke of piston, and large steam openings, are frequently found running at the rate of *five to six hundred revolutions per minute,* for driving large circular saws, the saw being on the crank shaft, and requiring the engine to be driven the same number of revolutions as the *saw.* This class of engines is mostly built at Salem, Ohio, at the Buckeye Shops, and at the Salem Iron Works. An engine lately built by the latter firm for a party in the State af Michigan, was of the following dimensions: Diameter of cylinder, sixteen inches; stroke of piston, twenty-four inches; running two hundred revolutions per minute, and driving two fifty-four inch circular saws (by belts) seven hundred revolutions per minute. One of these saws containing thirty teeth was tested, and the chips (not dust), measured one-eighth of an inch each, which gives a cut of three inches and six-eighths to each revolution of the saw, or at the rate of two hundred and eighteen feet per minute; but allowing for time to run back the carriage and shift the log, this rate will be reduced fully one-half; and yet this seems almost impossible. However, we have seen and measured some of the chips that were forwarded in a letter to Messrs. Sharp & Davis, of the Salem Iron Works. The circular saw was made by Mr. Henry Diston, of Philadelphia, to the order of Messrs. Sharp & Davis, of Salem, Ohio. This engine and saw are guaranteed to cut fifty thousand feet of lumber in ten working hours

Another thing in these steam mills, is the small amount of steam room or boiler. Below is the result of a trial made a few years ago by Messrs. Sharp, Davis & Bonsall, of the Buckeye Machine Shops, of Salem, Ohio.

"We attached two of our engines to a single boiler sixteen feet long, forty inches in diameter, with two fourteen inch flues. One

of the engines with a six and a half inch bore, seventeen inch stroke, and attached directly to a mulay saw, cut, from twenty-three poplar logs, 12,229 feet, all inch boards except 1,100 feet of one and a half and two inch plank. The other engine with a six inch bore, fourteen inch stroke, and attached directly to a fifty-four inch circular saw, cut from forty-three poplar logs, 14,948 feet, all inch boards. The work was all done between the hours of six o'clock, A. M., and 5-10 P. M., of the same day. Running time on the mulay mill, nine hours; and nine hours four minutes on the circular mill—which time included putting on and off the logs. Thus we have 27,177 feet of lumber sawed in nine hours and four minutes by the steam generated from *one* boiler sixteen feet by forty inches, two flues—being equal to only 240 feet of fire surface. The only fuel used during this trial was two and a half cords of slabs and poplar bark, about equal quantities of each. As to the amount of fuel thus used, we claim no particular saving; for, to burn that amount of fuel under that boiler in so short a time, a very lively fire must be kept up; and to burn the same fuel in the same time under a similar boiler of fifty per cent. more fire surface, fifty per cent. more steam would be generated, and a corresponding amount of sawing done."

The engine is placed by the side of saw-frame, and its shaft extends across the frame and receives the saw directly on its outer end—both engine and saw making the same number of revolutions. The boiler is usually placed so as to bring the engine immediately between the boiler and saw-frame, but it can be placed so as to be most convenient to the fuel. The speed of these mills is from 400 to 500 revolutions per minute, and as high as 700.

Occlusion of Gases by Metals.—We have, at former times, made brief notice of this subject, in connection with the theories now best supported, as to the chemistry of acieration or the manufacture of steel from wrought iron; and also in connection with the subject of Celestial or Astronomical Chemistry, and we now propose to make a more complete résumé of the whole matter, in the shape of an abstract prepared from the address on this subject, delivered by Wm. Odling, M. B., before the Royal Institute, May 17th, 1867, and printed in the volume of *Proceedings*, just published.

The fact that various metals heated to a point in the vicinity of redness, allowed certain gases to permeate them, first noticed by Deville, in the case of iron and platinum, was proved by Graham to exist in a far greater degree and at a lower temperature with palladium, which allows some hydrogen to pass at 240°, and a con-

siderable flow at 265° and above, though impervious to air even at a red heat. This action, was also shown by Graham to differ entirely from the ordinary phenomena of transpiration and diffusion, and to involve an absorption of the gas by the metal, dependant upon special relations between the two.

Many of these relations have been carefully tested, and some of

	NAME OF GAS OCCLUDED.	VOLUME OF GAS GIVEN OFF IN PER CENT. OF VOLUME OF METAL.
Platinum wire from fused metal.............	Hydrogen	21·
Same wire drawn to four times the length.	"	17·
Spongy platinum..............................	"	148·
Wrought platinum, one specimen in several experiments......................	"	553·493·383. Av. 476.
Palladium foil heated to 245° and cooled, treated as before......................	"	52·600 or 526 vols.
Palladium foil heated to 90°–97° for three hours, cooled and treated as before.	"	54·300 or 643· vols.
Palladium sponge heated to 200° &c.......	"	68·600 or 686 vols.
Palladium foil at common temperature absorbed and yielded by same treatment.	"	37·600 or 376 vols.
Palladium foil absorbs also certain liquids.	Water, Alcohol, Ether,	0·1 per cent., 0·15, and 0·55
Copper wire......................................	Hydrogen	30·
" sponge...	"	60·
Gold—assay cornettes........................	"	48·
" " "	Carbonic oxide	29·
" " "	" acid	16·
" " "	Air, almost all N.	20·
" " "	Natural gas expelled by first heating in vacuo. H & CO.	212·
Silver wire..	Hydrogen	21.
" "	Oxygen	74·
" sponge..	Hydrogen	92·
" "	Oxygen	722·
" "	Carbonic acid	52·
" "	Carbonic oxide	15·
" leaf in air..................................	Oxygen, nitrogen	137· and 20·
Iron wire..	Hydrogen	46·
" "	Carbonic oxide	415·
" "	Natural gas expelled by first heating in vacuo. CO.	700· to 1250·
Meteoric iron from Lenarto	Hydrogen 85 p. ct. of entire yield, rest N and CO.	275·

the results will be found above, where we have arranged them in a tabular form, for the sake of brevity.

The substances mentioned were heated and allowed to cool in an atmosphere of the gas named, and were then again heated in a glass or porcelain tube, kept exhausted by a Sprengel air pump, the gas extracted being carefully measured.

Several of the facts expressed in the above table, are worthy of special note and consideration. Thus we see that wrought platinum absorbs on the average 476 per cent., or about five times its volume of hydrogen, but this is the bulk of the gas measured cold after its extraction. When it was absorbed, the temperature was about 1400 F., which would give it a volume fifteen times that of the mass of platinum, by which it was imbibed. To condense or compress the gas to this degree in a space otherwise unoccupied, would require a force or pressure of fifteen atmospheres, but this compression is accomplished in a space already occupied by one of the densest of metals, the interstices between whose ultimate particles we cannot conceive as occupying more than the $\frac{1}{1000}$th of its total bulk. To compress the fifteen volumes of gas into this space of $\frac{1}{1000}$th of a volume, would demand a force of no less than 15,000 atmospheres, or 225,000 pounds per square inch, and yet to this almost inconceivable power, we here see the atomic attraction between the particles of the metal and gas is proved equal.

But if this statement staggers belief even in the face of demonstration, what shall we say to the case of palladium, which absorbs not five but 643 volumes of the same gas.

In this latter case, the gas so occluded, is in part lost at ordinary temperatures and conditions of atmospheric pressure, but with platinum the gas occluded is held firmly even in a vacuum at 220°, and even at a heat a little below redness. At a temperature sufficient to soften glass (500°), 1·72 c. c. of H were collected in ten minutes, and in a combustion furnace 8·2 c. c. in an hour.

The temperature required for absorption of hydrogen by platinum is much below that at which the gas is again released; thus, some foil absorbed 76 per cent. at 100°, and 145 per cent. at 230°.

The condensed hydrogen has the properties of the nascent gas. Thus, palladium so charged, reduces permanganate of potash, bleaches iodide of starch, throws down Prussian blue from ferrocyanide of potassium.

The absorption of carbonic acid by iron, has a marked connec-

tion with the theory of acieration, as we have pointed out on a previous occasion, when this fact was first discovered, and applied in this explanation. At a low temperature in the cementing oven, also carbonic oxide (2 CO) is no doubt absorbed by the iron, and at a higher heat is decomposed, yielding part of its carbon to the iron for its transformation into steel. Thus two equivalents of carbonic oxide (2 CO) liberate one equivalent of carbonic acid, and giving one of free carbon to the iron. The carbonic acid as it escapes produces the well known phenomenon of blistering.

We also see that wrought iron acquires in the process of manufacture, a change of from seven to twelve volumes of carbonic oxide, which it carries with it ever afterwards.

To the conclusions to be drawn from the presence of hydrogen in large amount in meteoric iron, we have alluded at some length before, and will at this time simply insert a reference to this former discussion (see Vol. 54, p. 16 of this *Journal.*)

The Brooks Insulator.—In our last issue we promised to give the results of tests made in our presence, in which the merits of the Brooks Insulator were compared with those of other forms. We will now give the tests made in Philadelphia, April 22, 1868. The testing instruments employed were a set of resistance coils, made at the Silverton Works, and a Ruhmkorff Galvanometer of admirable construction, whose delicacy was such that the contact of one finger, with a brass bending screw at one terminal, while a finger of the other hand rested on a copper wire at the other terminal, deflected the needle several degrees. The results are reduced to ohmads of resistance to make them comparable with the Silverton experiments, in which a far more sensitive galvanometer was employed, and a more powerful battery.

The constant of the galvanometer was first determined by passing the current of one of the sulphate of mercury cells described by Mr. Chester, p. 257, of our last volume, through a resistance of 10,000 units or ohmads and the instrument. This gave an actual constant for one cell of 6,160°, or for the entire battery of 151 cells, afterwards employed, of 930,160.°

One pole of the battery being then connected with 88 Brooks insulators, and the other through the galvanometer to the earth, a deflection of 8° was observed, giving for each insulator a deflection of $\frac{8}{88} = \frac{1}{11}$ of a degree, which represented a resistance under the conditions described above, of 102,317,600,000 ohmads.

At the same date, a trial was also made with 22 earthenware insu-

lators, charged with paraffine by the same method as for the other insulators. The deflection in this case was 17° or $\frac{17}{22}$ per insulator, which being reduced as before, gives 12,037,365,902 ohmads.

There was then immediately a trial made with 22 glass and bracket insulators, the kind generally employed in this country.

The deflection here measured was 7852°, or $356\frac{10}{11}$ per insulator, showing a resistance in ohmads of 2,605,000.

The atmospheric conditions under which these experiments were made were as follows: It had rained steadily on the 20th and 21st until evening, when a fog formed and continued until 8 A. M. of the 22d, when the deflections were greatest, and were measured as before stated.

The Silverton tests on March 31st, the time of greatest deflection, reduced to ohmads, stand as follows:

United Kingdom Tel. Co.'s large porcelain...	4.087.500
Varley's double porcelain cup.....................	8,270,000
British and Irish Mag. Tel. Co.'s porcelain...	2,725,000
United Kingdom's Tel. Co.'s small porcelain	8,270,000
Brooks' patent..	40,875,000,000
" "	40,875,000,000
" "	163,500,000,000
" " lug for crossarm....................	54,500,000,000

Several points are here worthy of remark. First, the English tests give a higher actual resistance for the Brooks instrument than those made here. This is undoubtedly due to a better state of the weather. Such a favorable condition for putting to test the efficiency of insulators, as was furnished on April 22d, is, fortunately for the telegraph company, not often to be met with. Again we see that the various English insulators tested were ahead of our usual glass and bracket, while these in their turn were left, each further in the rear, by the Brooks apparatus.

The constant of this galvanometer made by Ruhmkorff, is, as we have already seen, 6160°, with a single cell through 10,000 ohmads, while that of Prof. Thompson, used in the Silverton tests, has a constant of 335° through 1,000,000 ohmads, or 100 times the resistance, thus showing that the delicacy of the English instrument was five times as great as the French.

There is, indeed, no question, that in all such matters, if connected with the application of scientific principles and accurate measurements to the practical working of telegraphic lines, the English are decidedly in advance of all other nations. On the other hand, there

are a vast number of ingenious contrivances and simple ways of securing good results, in constant use here, which are unknown abroad.

Effect of Surface on Radiation.—In a late address before the Royal Institution, Mr. Balfour Stewart employed the following interesting experiment. A cannon ball with chalk marks upon it, and a tile with a pattern in white and black upon it, were heated to redness and viewed in a darkened room, when it was found that the black parts of both objects emitted more light than the white ones.

Hard Water.—Dr. Clark's most ingenious process for softening hard water containing carbonate of lime, dissolved in excess of carbonic acid, by adding an additional amount of lime, which, taking up the free carbonic acid, caused all the carbonate of lime (insoluble in pure water), to be precipitated; has been thoroughly tried in London, but proves impracticable, on account of the enormous quantity of precipitate formed where such vast volumes of water were treated. This we learn from a paper read before the Royal Institute, by Mr. E. Frankland, Professor of Chemistry to that institution. In the same paper, we learn that one-third of a pint of milk contains more lime than two quarts of this very hard London water, so that any claim to importance as a source of lime to the system, is thus denied to that otherwise so objectionable beverage.

Editorial Correspondence.

LETTER FROM THE ABBÉ MOIGNO.

Paris, July 30, 1868.

A NOVEL and ingenious microscope has been invented by Signor Marco Caselli, of Rome. It consists of a magnifier, one of whose sides is silvered by precipitation with the aid of organic substances. If we place an object in front of this lens at a proper distance, we obtain a well magnified virtual image. Two convergences and one divergence contribute to produce the magnifying power:—1. The convergence of the rays entering the lens. 2. The divergence of these rays by the silver concave mirror at the back. 3. The convergence of these rays on quitting the upper surface of the lens.

The mirror-lens is placed horizontally, or slightly inclined, so as to

keep at a distance the image of the object. Above it, and fastened to the same pillar, is the horizontal diaphragm on which the object is placed; this is furnished with a screw and rack-work, so as to be raised or lowered at will. Above this, at a short distance, is placed a screen of white or almost colorless card-board, at an angle of 45 degrees, and pierced exactly over the centre of the mirror-lens, with a small hole, through which the image is seen. This card also serves to reflect light on the mirror-lens, and to make the image appear on a white ground.

With this microscope, there is no need of the usual lenses, nor mirror to light up the object, since the mirror-lens itself causes the light to converge on the object.

M. Richner, of No. 4 Rue du Hasard-Richelieu, Paris, has invented a very ingenious little apparatus, very much needed for announcing, by a bell, the arrival of the moment for mounting or winding up a moderator or a carcel lamp, especially for the moderator, in order to prevent the wick from smoking, becoming carbonized and being extinguished. The contrivance consists of, 1. A movable clip, which fits into the space between two teeth of the vertical rackwork of the lamp, and is furnished with slotted projections, into which fits the tail of a hammer or striker. 2. A bell, which the hammer strikes when the fall of the rack brings down the projection of the clip; this is placed always on the side opposite to that of the overflow drip, in order to prevent the oil from inundating the bell. When the rackwork is wound up, the tail of the hammer lets the projections of the clip pass by, this latter then assuming its natural position.

Two new steamers—the first of the kind ever built here—have just been launched in the very bosom of Paris. They have been constructed by M. Casimir Deschamps, for raising sunken vessels, and they received the names of *Le Persévérant* and *Le Bonespoir.* Their peculiar build and graceful form of rig, the difficulties under which they were built and launched, and the fact of M. Deschamps having been originally bred up as a sculptor, render the details of this vessel of practical interest to the mechanical world.

Both vessels are alike in size and rig; length 59 feet, breadth 9 feet 10 inches; depth 10 feet 6 inches, about 150 tons. Commenced on the 1st October, 1867, they were fully completed in May last, and launched, masted and rigged. The canal of La Villette, near which they were built is only 66 feet wide, so that the launching was attended with extreme difficulty. What is most extraordinary, is, that these ships of wood, strengthened by iron ribs, sheeted with

riveted iron plate, and covered with Stockholm tar, all complete, masts, sails, in fact everything necessary for sea, have sprung up as if by enchantment, without any master shipwright, engineer or mechanician. M. Deschamps made his drawings in a small, wooden office, put them to working scale, and executed them himself, aided by simple Parisian carpenters, joiners and smiths. On this comparatively gigantic work, he spent only £4,800, whereas the shipbuilders of Havre, Cherbourg and Nantes, demanded from £6,000 to £6,400 for the same work.

As the first of their kind, these boats are constructed upon a completely new and perfectly combined system. By their rounded form, which gives them more volume and stability, they remind us of the good steamers which ply directly between Paris and London. The hull is divided longitudinally into two portions, containing each thirteen chambers, separated by thick iron plate diaphragms, destined to contain alternately water and air; perfectly impervious to water or air, under a pressure of five atmospheres, they can remain separate or be made to communicate with each other at will. Two series of tubes, furnished with valves and a cock opposite each compartment, run along the whole of the deck, in the middle, and place the chambers in communication with the pumps which either exhaust the water or pump in compressed air. Each water tight compartment has, besides, a man-hole, so that the bottom can be inspected, or a boy can descend. Lastly, well-holes have been made, between the two longitudinal series of chambers, from distance to distance, traversing the whole of the ship from the deck to the water. These are for the passage of the chains, which are passed under the sunken vessels, in order to raise them.

The ends of these chains are wound round a very massive iron drum of a windlass, set in motion either by steam or manual power, and capable of lifting 25 tons. In order to raise a shipwrecked hull, either one or both of the vessels can be used according to circumstances. The method is very simple; the steamer is brought exactly alongside the wreck, and the compartments are filled with water sufficiently to sink the caissons to nearly the level of the water; the chains are then passed under the sunken hull, and wound tight by means of the drums. On the water being pumped out of the steamer's compartments, the wreck is raised from the bed of sand or mud which it occupied.

The interior dispositions of these ships are no less satisfactory. In the forecastle we find the captain's cabin 13 feet square; amidships,

the air and water-tight compartments; abaft, the engineer's and stoker's berths, the coal bunker, the boilers and engine. There are two boilers, one of five another of ten horse-power, and an American motor of ten horse-power, fitted with Giffard's Injector, &c. We are able to state, to his praise, that for boilers, engines and the rest of the machinery, as well as the propelling screws, M. Deschamps addressed himself to the most careful and trustworthy constructors. He has neglected nothing, and his spirited efforts we are sure will be crowned with complete success.

M. Caron (commandant), has published a memoir on the composition of a gaseous mixture serving for the oxyhydrogen light, and a new material to be substituted for the magnesia cylinders. He has found that these latter cannot resist, indefinitely, the intense heat produced by the combustion of ordinary coal gas mixed with oxygen. This volatilization of the magnesia may be due to the formation of reduced magnesium, which M. M. H. Deville and Caron found to sublime very easily. (This is the process now most in vogue for purifying this metal.) Considering that, in order to obtain the greatest light, the gaseous mixture should always contain an excess of hydrogen, the combustible and the reducer, M. Caron made experiments in which he measured the quantities of the two gases (pure hydrogen and oxygen), and fully demonstrated the above fact. When substances oxydized at a maximum, but capable of being reduced to a minimum by hydrogen, are exposed to high temperatures, and under the same conditions of the composition of the gases, we are certain to find, after extinction, that the portion of the pencil or cylinder, exposed to the flame, has been converted into an inferior oxide. Thus, for example, titanic acid, heated in oxygen to the highest temperature, does not melt; but submitted directly to the flame of a lamp (containing an excess of hydrogen), it melts immediately, and, yellow as it had been, becomes blue and sometimes black. A very curious phenomenon is also remarked. In regulating the gases so as to obtain the maximum of light, a burst of sparks proceed from the crayon, similar to those produced by iron burning in oxygen. This is, in fact, the titanic acid, reduced at first, but re-oxydized afterwards in the midst of air and aqueous vapor. The shower of sparks ceases immediately on slightly increasing the supply of oxygen. The tungstic, niobic, and tantalic acids possess equally this fusibility, even in a high degree, for when heated to a white heat in a platina crucible, by means of a Schlœsing blowpipe, they always melt if the flame contains an excess of hydrogen. They

crystallize on cooling, and become discolored. The titanates, tungstates, &c., with a magnesian base, also melt and turn black in the oxyhydrogen flame; all these substances are thus unsuited for lighting purposes. Silica, alumina, and the refractory earths melt and give out little light. After examining the effects of glucinium, the oxides of chromium, of cerium and of lanthanium, M. Caron tried silicate of zirconium, of which he knew the infusibility; but as he expected, the pulverized and agglomerated zircons gave very little light (which happens, in general, with all the silicates.) He resolved to try ZIRCON. According to Berzelius, this earth has the property of being infusible, and giving out a light of dazzling brilliancy in the flame of a blowpipe. This, M. Caron found to be true, and he has employed the same crayon in the flame of the oxyhydrogen jet, without the least sign of wear, volatilization, or even partial reduction. This is very important, for the incandescent matter must remain always at the same distance, and if the pencil wore away, the distance would increase and the light diminish.

The use of ZIRCON in the oxyhydrogen light, is a valuable discovery, for, in addition to its being unalterable, the light is superior to that of magnesia in the proportion of 6 to 5. Though, at present, rare, ZIRCON exists in many volcanic sands, and in great abundance in the zirconean rocks, near Mark, in the environs of Ilmeusea, at the foot of the Ural Mountains.

M. Caron has also found a very simple method of economising the substance, by only applying the zircon to that portion of the crayon exposed to the flame; the rest can be made of magnesia or even refractory clay. By compression, the zircon adheres to the other substance, and burning adds to the solidity of this adhesion.

Zircon crayons are made in the same manner as those of magnesia

F. MOIGNO.

[Preparations are now going on in New York for a practical trial of the new method for the manufacture of oxygen, by heating manganate of soda in alternate currents of air and steam.

We had also the pleasure of witnessing, in the laboratory of Dr. Doremus, various experiments conducted by him with the little pencils of compressed magnesia, referred to above by the Abbé Moigno. The pencils were unaffected by the air and remarkably enduring under the action of the flame of illuminating gas and oxygen, which was directed upon them.—ED.]

Civil and Mechanical Engineering.

PNEUMATIC BRIDGE FOUNDATIONS.

By O. Chanute, C. E.

(Concluded from page 28.)

Busswill Bridge.—At the Busswill bridge, over the Aar, in Switzerland, both the abutments and the three river piers, were founded upon iron caissons, surmounted with masonry, and sunk to a depth of 49 feet below low water.

The caissons, weighing on an average 71,662 pounds, were rectangular, 13 feet 9 inches wide, 39 feet 4 inches long for the piers, and 35 feet 5 inches long for the abutments. The working chamber was 8 feet 10 inches high, and the sides of ⅜ plate, stiffened by 26 iron beams supporting also the roof. The latter was but ¼ inch thick, and was found rather weak in the process of sinking, though strengthened by the 26 side beams, as well as by 9 transverse and 2 longitudinal iron beams.

Above the working chamber, a sheet iron skin of No. 14 plate, was carried up in order to form the coffer-dam, and protect the fresh laid masonry from the friction of the soil in sinking.

Each caisson was suspended by 12 screws, and the excavations extracted by a central dredge, working in a tube 6 feet 3 inches diameter of ⅜ plate, while the two air chimneys (of which only one was used), were 2 feet 11½ inches diameter, and ⅜ thick.

As such light caissons would have buckled, and might have been crushed by the side pressure of the soil in sinking (the much stronger caissons at Kehl having been somewhat crippled, and required vaulting), brick arches laid in cement were laid inside between the side beams, before the process of sinking was commenced, so that the caisson was in fact a brick vault, surrounded by the iron work and supporting the pier.

The air compressing engine was made of two old locomotive cylinders, mounted on an oak frame, worked by an engine of 20 horsepower, erected on the left bank of the river. The air was conducted to the workings through cast iron pipes, with India rubber joints, laid on a temporary bridge built to expedite the transportation of materials.

With these arrangements, the five caissons were successively put

down, the masonry built, and the superstructure (erected upon one of the banks), rolled over the piers into place as fast as each pier was completed. The whole work was done in one year, and as will hereafter appear, at considerably less cost than bridges founded with tubes.

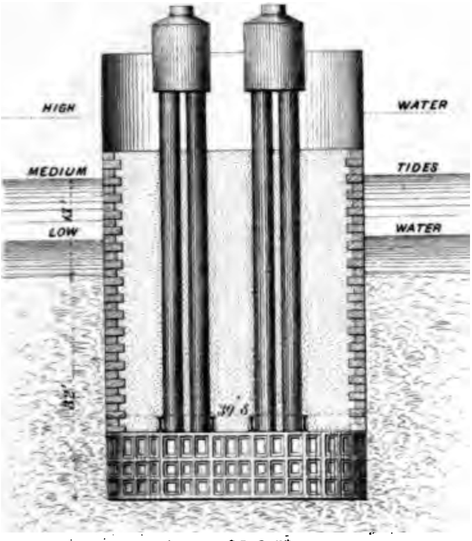
Scorff Viaduct.—At the bridge over the Scorff, at Lorient, built in 1862, by M. Croisette Desnoyer, as chief engineer, it was at first proposed to found the two intermediate piers, carrying the metallic spans of the viaduct (the approaches being of masonry arches), each upon two tubes of 14 feet 9 inches diameter, put down to rock, filled with cut stone masonry, as they were to be in salt water, and surmounted above low water by a masonry pier resting upon an arch turned over the two tubes. This arrangement was deemed necessary in order to insure stability, the lower chord of the bridge being 105 feet above the rock, at the deepest foundation.

The bids of contractors, for foundations, on the engineer's plans, exceeded his estimates, but Messrs. E. Gouin & Co. offered to furnish the foundations up to low water mark, in one solid mass of cut stone masonry the size of the pier, at the engineer's estimates for tubes, provided they were allowed to substitute caissons: as this proposal afforded about twenty per cent. more base, in a single homogeneous mass, and at a less cost, it was gladly accepted.

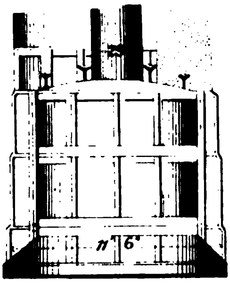
The Scorff is here in a tide-way. At extreme high tide, there was 23 feet of water and 46 feet of silt over the rock at the site of one pier, and 23 feet of water and 26 feet of soft silt and mud over the other. The surface of the rock was rough and broken, so that it was necessary to quarry it, before a good bearing could be obtained for the piers, and this had to be done at a depth of 49 and 69 feet below high water, while the action of the tides considerably complicated the precautions to be taken in carrying on the pneumatic process.

M. Gouin built for each pier a boiler plate inverted caisson, or working chamber, 39 feet 8 inches long, 11 feet 6 inches wide, and 10 feet high, the plates increasing in thickness from the bottom, and being $\frac{1}{2}$, $\frac{3}{8}$, and $\frac{5}{16}$ thick. The roof was made of $\frac{3}{8}$ plates, and slightly arched, as the full weight of the masonry was to rest upon it in the process of sinking. Its interior framing consisted of a series of curved wrought iron beams, abutting against cast iron struts, extending from side to side, to resist the pressure of the soil, and the roof was sustained by four transverse built beams, $27\frac{1}{2}$ inches deep, and four longitudinal rows of 8 inch **I** beams. There was a slight batter

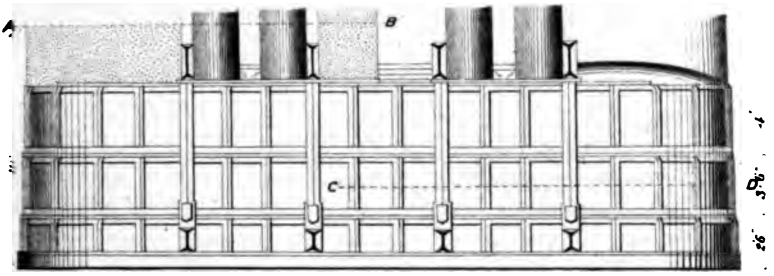
Bridge at Lorient.



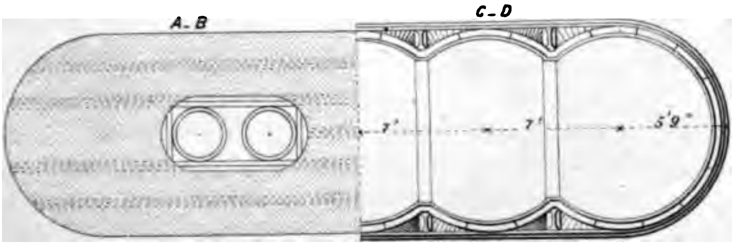
SECTION OF PIER.



CROSS SECTION THROUGH CAISSON.



LONGITUDINAL SECTION.



PLAN OF CAISSON

in the sides, which, in connection with the narrow width, proved to be a mistake, and only 4 inches retreat provided all round to offset possible irregularities in sinking, which was found quite too small.

Above the working chamber, a sheet iron enclosure or coffer-dam extended to low water, made of successive zones of $\frac{1}{4}$, $\frac{3}{16}$, and $\frac{1}{8}$ plates, rivetted on as the sinking progressed. The weight of each working chamber was 60,858 pounds, and of each surmounting coffer-dam 33,957 pounds. The general arrangement of the pier and the caisson is shown on Plate V.

As the nature of the silt and mud was such that dredges could not excavate it to advantage, and the area of foundation was much smaller than at Kehl, the materials were withdrawn in boxes through four air chimneys 27½ inches in diameter, placed in pairs, and surmounted with an equilibrium chamber 8 feet 2 inches diameter, and 9 feet 10 inches high, of which the lower part was in communication with the air tubes, and the upper part comprised the two air locks.

Operations were begun on the deepest foundation—that on the right bank. The surface of the soil was here 23 feet below high tides, or 13 feet below medium tides, but the caisson having settled by its own weight some 2 feet 8 inches into the mud, it was only at this depth that excavation in compressed air began. It was soon found that there was considerable danger of side lurches or tipping of the pier, and that the excavation had to proceed with the utmost care. The narrowness of the working chamber (11 feet 6 inches), in proportion to its length, the side batter, as well as the softness of the silt, united with the action of the tides to give it very unstable equilibrium.

In order fully to appreciate the action of the tides, it should be remembered that in order to keep the pier within the control of the suspending screws, the weight with which it is loaded should never be much greater than that necessary to overcome the friction on the sides, and the reaction of the compressed air. As the tide rises and falls, the depth of immersion and consequent displacement of the pier is constantly changing, and the equilibrium is destroyed. The caisson tends either to be lifted up by the reaction of the compressed air at the flood, or to go down suddenly at the ebb. By slightly varying the pressure, these effects were somewhat diminished, but they could not be fully overcome, as the pressure had to balance the head of water in order to prevent it from rising up inside the working chamber.

At the pier on the right bank, the soil was composed of silt with a certain consistency, so that no very serious trouble occurred, yet when the rock was reached, the pier had tilted a little towards one side, so that the four inches offset provided were lost, and the masonry had to be carried up plumb upon one face, in order to keep within the base. Another difficulty occurred, however, the coffer-dam surmounting the working chamber had buckled irregularly, so as to prevent carrying up the pier inside of the full intended size, and it even became necessary to cut away the plates at the upper end, and to work only at low water, in order to lay the upper starling.

At the pier on the left bank, although the depth to be attained was less, far greater trouble was encountered. The soil was here of soft mud, offering but slight lateral resistance, so that soon after beginning operations, the pneumatic pressure having suddenly diminished, in consequence of an accident to the blowing engine, the caisson went down all at once with a lurch, and was filled to the very roof with mud. Happily there were at the time no men in the working chamber. In going down, the caisson had tilted to the rear, and the iron skin of the coffer-dam, pressed against the masonry which filled it part way, had been torn open just above low water. The masonry at this point was yet above low water, but it was dangerous to build any more on top of it, for fear of lurching the pier still farther.

Under these circumstances, excavation was resumed in the working chamber on the up stream side, while a strong wooden platform, well strutted to the roof, was placed upon the mud inside the caisson at the lower end, so that the weight might rest upon the soil, and not upon the cutting edge. By excavating with care at the upper end, the caisson was gradually righted up, and brought back to its normal position, while the masonry was run up above the rent in the coffer-dam. The descent to the rock was then continued, not without fear and trouble, but at least without serious accident.

When the rock was reached, it was found, as expected from the borings, very irregular, there being differences of five feet in the height, within the limits of the caisson. As it was very hard, and powder could not be used within the working chamber, it would have taken a great deal of time to quarry it so as to bring the whole of the cutting edge to a proper bearing. It was, however, quarried so as to give the edge a bearing for about $\frac{4}{5}$ths of its perimeter, and for the remainder, sheet piles were driven below the edge to the rock, so as practically to prolong the working chamber, the mud

inside excavated, the rock cut in steps and cleaned off, and the caisson filled up with concrete to the roof, with all possible care.

Six months and a half were employed in founding the first pier, of which the erection of the caisson and machinery occupied three months; for the second pier, as the company were in a hurry to open the bridge, the work was pushed very actively, yet three months were consumed in putting down the foundation through the twenty-six feet of mud overlying the rock, eleven days in concreting the working chamber, and seventeen days in building the pier above the foundations.

Nothing would be more fallacious, says the engineer in charge, in the account of the works from which this description is condensed, than to base calculations upon an assumed daily rate of progress, for such works are subject to many eventualities and accidents, and the time occupied depends chiefly upon the interruptions and breakages which occur from various causes. It should, however, be remembered, that at Lorient, the irregularities of the rock, the softness of the mud, and especially the action of the tides, presented great difficulties.

Messrs. Gouin & Co. have since founded in a similar manner, upon pneumatic caissons, the piers for the bridge over the Po, at Mezzani Corti, a description of which will be found in *Engineering*, Vol II., p. 329, and Vol. III., p. 193.

The average cost per pier of pneumatic foundations have been as follows:

BRIDGE.	SYSTEM.	DIAMETER.	AREA OF BASE.	HEIGHT.		AV. COST FOR ONE PIER.	
				BELOW WATER.	ABOVE WATER.		
Macon..........	2 tubes	10 ft.	157 [] ft.	49 ft.	33 ft.		$16,182
Bordeaux........	2 "	11 ft. 9 in.	217 "	52 "	28 "		21,535
Orival..........	2 "	11 ft. 9 in.	217 "	$48\frac{1}{2}$ "	34 "		21,945
Busswill.........	caisson	$39\frac{1}{3} \times 13\frac{3}{4}$	540 "	49 "	15 "	$8,738	
Busswill.........	masonry					6,607	15,345
Lorient..........	caisson	$39\frac{2}{3} \times 11\frac{1}{2}$	456 "	59 "	36 "	19,530	
Lorient..........	masonry					7,834	27,364

The tubes being carried up to the bridge seat, and forming the pier, the cost of the masonry surmounting the caisson is added as above, in order to afford a correct basis of comparison.

As these works were executed at gold prices, with cheap iron and labor, and with the aid of experienced contractors, possessing complete outfits and tools required for the pneumatic process, it is probable that the cost of similar works at present prices in this country, would be from two to four times the cost abroad. Let us, for instance, take the best managed and cheapest of these bridges, that of Busswill, and apply prevailing prices here to the actual quantities in execution; the result will be as follows:

ITEMS.	QUANTITIES.	COST AT BUSSWILL.	COST IN UNITED STATES.	
			PRICE.	AMOUNT.
Caissons lowered in place.	46,100 lbs.	$2,668	11 cts.	$5,071
Iron skin for coffer-dam..	25,560 "	1,211	10 cts.	2,556
Sinking foundation	49 feet	1,968	$1,20	5,880
Hammer-dressed masonry below water..................	706 cub. yds.	4,198	$16	11,296
Cut stone masonry above water	242 " "	2,409	$25	6,050
Totals............		$12,454		$30,853
To this must be added a proportion of the general expenses, cost of scaffoldings, use of tools, &c.		2,891		7,200
Totals............		$15,345		$38,053

There being five foundations to put in at Busswill, the proportion is arrived at as follows:

	AT BUSSWILL.		IN UNITED STATES.	
	WHOLE COST.	ONE-FIFTH.	WHOLE COST.	ONE-FIFTH.
⅕th cost of temp. bridge...	$1,820	$364	$3,000	$600
⅕th " " scaffoldings...	2,810	562	5,000	1,000
⅕th " " use of tools...	8,626	1,725	25,000	5,000
⅕th " " temp. build'gs.	1,200	240	3,000	600
Totals.............	$14,456	$2,891	$36,000	$7,200

Up to a pressure of 1 or 1½ atmospheres, corresponding to a depth of 33 to 49 feet below water, although the workmen must be selected with special reference to their temperaments, and ability to resist compressed air, no serious ill effects generally result to their health, beyond severe pains and lassitude upon emerging, and occasional deafness. Beyond these depths, however, it may be necessary, as was done at Kehl, to establish an hospital at the works, and to have a physician in attendance in order to relieve cases of asphyxia, and treat the numerous instances of illness which arise.

It will thus be seen that the pneumatic is anything but a cheap process, but that whenever it becomes necessary to resort to it, the stability of the pier will be greater if founded on caissons than on tubes, while the cost of a given area of base will be less. Beyond the very complete command which it gives over the uniformity of the undermining and the removal of obstructions, and also probably the effects of the air escaping from under the lower edges, in diminishing the friction of the soil, it is a positive detriment. It counteracts a large proportion of the load in sinking, it causes serious accidents in case of breakages in the blowing machinery, air-pipes, joints or tubes; it compels the use of special workmen at high wages, and endangers their health; and it does not always lead to economy of time, particularly when special machinery has to be constructed to employ it. Wherever rock is not very deep below the surface, or the circumstances of location admit of it, the present high prices of iron and labor, and the want of adequate plant for the pneumatic process in this country, will probably make it cheaper and more

judicious to resort to other methods, such as bottomless caissons, sheet pile coffer-dams, or even wooden pile foundations.

Mr. McAlpine has recently so ably pointed out in this *Journal*, the danger, under certain circumstances, of trusting to piles sustained exclusively by the friction of the soil against their sides, that engineers will generally agree that it is unsafe to resort to them in locations subject to deep scour. Yet, as in consequence of their cheapness, and the rapidity with which they can be put down, pile foundations will always offer strong temptations to the engineer, it may be deemed important to inquire under what circumstances they may be safe in our great western rivers, which flow over beds of sand.

The chief danger to the stability of piers, aside from shocks from ice or other floating objects, arises from possible unequal scour upon their opposite sides, thus undermining on one side, while the whole thrust of a bank of saturated sand is exerted on the other. In a recent instance, at one of the bridges now building in this country, a sudden freshet scoured out twenty-five feet deeper on one side of a bottomless caisson in process of sinking than on the other, and upset and destroyed the works, and the belief is entertained that had the foundation been put down with tubes, columns less than twelve or fifteen feet in diameter, would not have been safe against this action.

Unless turned by obstacles, the Mississippi and Missouri rivers, in sweeping from side to side of their valleys, make a succession of pairs of reversed curves, generally abraded by the current to the same radius, with straight reaches between them. The channel crosses the bed of the river diagonally between the curves, impinges against the shore, and is reflected towards the opposite bank. The straight reaches occur at the foot of the lower curve, where the resulting angle of reflection assumes a direction nearly parallel with the shore. The changes which take place in the shores on both sides, present a series of interlocking, SS, proceeding down stream, the advancing eddy of the one filling up the bends excavated by the preceding S, and its current vein scouring out former sand bars; so that in a cycle of years, no obstacle intervening, the channel returns to its former bed.

As the building of a bridge across these streams, will generally involve the maintenance permanently of the channel through certain spans, the engineer will be led to locate the crossing just below

one of these curves, so that by making use of the impinging force of the current, the protection of one shore against further abrasion, shall give the command of both. Now the scour in these rivers during a flood is not uniform across their entire bed, but attains its greatest limit in the main high water channel, and decreases towards the convex shore, while, in consequence of the centrifugal action of the water towards one bank, and consequent slack current on the opposite shore, some points on the inside of the curve actually silt up during a flood. If the shore on the concave bank of the river above the bridge site be protected, so that no further advance in this direction can take place, it may be both safe and proper, even in the Missouri river, to put in pile foundations under some of the piers on the convex bank.

In the upper Mississippi, which has a far more stable *régime* than the lower river or the Missouri, it will probably be safe to found even the channel piers upon piles, provided they are properly driven to the rock, and if possible into it. They will then become columns of support instead of piles, the sand merely acting as braces to keep them in place. It will be necessary, however, to tie their heads firmly together, to protect them heavily with rip rap, and to keep it in repair, as otherwise, in case of partial scour, motion might ensue, and the foundation merely become a hinge for the pier to turn on.

In the Missouri, when the crossing is located just below a curve, a few foundations on the convex bank will be safe on piles; those in the channel, and *all* the foundations, if the crossing be upon a straight reach, must be carried down to rock, or below any possible scour, and must have sufficient base and weight to resist the thrusts to which they may be exposed. It will generally be found, moreover, that the bed rock is abraded deeper, and the scour greater on a straight reach than around or near a curve, and the channel more unstable. Should it be desired to confine navigation to certain spans, the shores must be protected above the bridge site, so that the angle of reflection, and consequent direction of the channel shall not change.

This sketch cannot better be closed than by translating the conclusion of a paper upon foundations, read before the Institution of French Civil Engineers, by M. Croisette Desnoyer, the chief engineer of the bridge at Lorient, which seems to resume very well the opinion of European engineers on this subject.

"The use of compressed air admits of penetration to very great depths in soft and permeable soils; it therefore affords a means of going down to rock, of clearing it off and leveling it, in locations where it would otherwise be impossible to reach it. It gives, consequently, a solid base for the foundations, and enables us to do the work with all necessary care, while it can be prosecuted almost without reference to the stage of water, so that work can be carried on almost at all seasons.

"But, as against these advantages, it presents great inconveniences. It may, at great depths, injure the health of the workmen. It threatens numerous chances of accidents. It compels long preparations, and finally, it is very expensive. This last circumstance, leads to reducing as much as possible the area of the foundations, and consequently diminishes their stability.

"Compressed air may be employed either in tubes or caissons. The tubes are more easily handled, and present fewer chances of accident in the sinking, but they are generally of small size, give but small bearings, and are only suitable for beam bridges. If they are of large diameter, they cost more than a caisson; (thus we have seen that at Lorient, a caisson was substituted without increased cost, for two tubes, 14 feet 9 inches in diameter), and they do not, like caissons, furnish a single homogeneous base. It is exclusively in caissons, therefore, that it is proper to employ compressed air for masonry piers, or for abutments founded upon soils likely to exert considerable side thrusts. In the latter case it will be sufficient to employ two parallel caissons, placed longitudinally. It would be well to adopt this arrangement, even for the abutments of iron bridges when founded upon oozy beds.

"Compressed air should evidently not be used for depths less than 10 metres ($32\frac{8}{10}$ feet), for up to this point, it would certainly be cheaper to put in the foundations, even in the middle of a river, either by the ordinary methods of excavation, or with submerged concrete. In still water, the ordinary methods of excavation may be carried to far greater depths than 10 metres in impermeable soils. Even when this last condition is not fulfilled, foundations may be put in upon wooden piles, provided it is found practicable first to test the soil by loading. In all these cases, the employment of compressed air would occasion greater expense, and should be avoided. It is best, therefore, to reserve this process, 1° for river foundations more than 10 metres in depth, 2° for very deep

foundations, in still water, in permeable soils where it is not possible to employ piles, or where, in consequence of the great importance of the work, this last method, even under good conditions, is not deemed sufficient.

"In any case, where the soil does not offer lateral support, it seems to us almost indispensable to increase the width of the caissons, by providing wide offsets at the base of the piers. The danger of lurches in the descent would thus be diminished, and the stability of the foundation much increased.

"Without ignoring any of the advantages of this powerful means of action, we therefore think that its employment should not be carried too far, and that, both on account of its great cost and of the chances of accidents which it presents, it is best to reserve it for difficult circumstances, where it would be nearly impossible to reach a good solution by the other processes."

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

By G. S. Morrison, C. E.

The problem of bridging the great western rivers, which has of late given so much interest to the subject of deep foundations, demands that equal attention be paid to the study of superstructures. The necessary expense of deep foundations calls for the introduction of much larger spans than have hitherto been found economical, and at the same time requires these long spans to be built with the least possible waste of material.

The form of truss in most common use is that known as the beam truss, the top and bottom of which are formed of two parallel chords, in distinction to parabolic trusses, in which the principle of the arch is used, and suspension trusses, in which a flexible beam is stiffened by a combination of bracing beneath it. The following pages will be confined to the discussion of beam trusses, and to deducing from a similar examination of the strains which act in them the most advantageous arrangement of the several parts. This will necessarily include a review of the advantages of making the same truss continuous over several spans, a practice in very general use among European engineers, and which leads to a saving sometimes as high as 25 per cent. in the intermediate spans of a bridge.

If a weight were placed upon a beam, and there were no lateral

adhesion between the successive parts of that beam, the weight would cut its way through by forcing down the portion under it, as shown in Fig. 1.

Lateral adhesion distributes the effect of the weight beyond the part of the beam directly under it. In Fig. 2, let A and B represent two adjacent points on which the weight exerts forces in the direction indicated by the arrows. If these forces were not disturbed, they would act along the lines AC and BD, but being diverted by the adhesion of the particles of the beam, they extend into the adjacent parts and act also along inclined lines represented by AE and BF, causing compression in these lines. The reaction of the material in these compressed lines will exert forces as indicated by the arrows; decomposing these reacting forces at the points A and B, into their horizontal and vertical elements, the vertical elements alone are balanced by the weight, and the horizontal elements tend to force the points A and B together, while at the lower side of the beam, the horizontal elements tend to draw the points E and F apart. The effect of the weight is, therefore, to shorten the fibres above and lengthen those below, thus changing their relative lengths and bending the beam, as shown in Fig. 3.

FIG. 1.

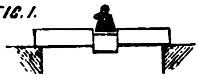
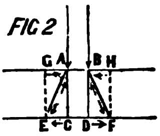
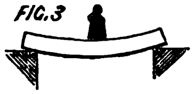


FIG 2



Hence, it appears that a beam under the influence of weight, which may be either its own or a superimposed weight, is subjected to strains of two kinds:

FIG. 3



1. A *shearing strain*, tending to cut the beam by causing one part to slide upon an adjacent part.

2. A *bending strain*, bending the beam by shortening the fibres above, and lengthening those below.

The economical construction of beam trusses lies in selecting the best methods of resisting these strains.

When a beam is bent, the outside fibres undergo a greater change of length than the intermediate ones, and consequently the intermediate fibres are less strained than the extreme ones. If all the material were concentrated at the top and bottom, the whole would be equally strained, and all act at the greatest advantage. Hence, in a beam truss, the material should be thrown into the top and bottom, leaving only enough between to resist the shearing strains. The

truss will consist of an upper and lower chord, whose function is to confine within safe limits the bending strain; and an intermediate web, whose function is to resist the shearing strain.

The shearing strains and construction of the web will be considered first, and an examination of the relations existing between the two kinds of strains and the methods of reducing the strain upon the chords will follow.

I.—Shearing Strains.

When a part of a beam is forced down between the adjacent parts; on one side, a surface on the right slides downward upon a surface on its left, and on the other a surface on the left slides downward on a surface to the right, or, relative position only being considered, a surface on the right slides upward on a surface to the left. These two motions being opposite, the strains which cause them should be represented with opposite signs. That shearing strain which tends to move the right hand surface downwards upon the left, will be considered positive, the reverse, negative.

When a beam, resting upon two supports, is uniformly loaded throughout, the whole weight is divided equally between the two supports, each bearing the weight upon the adjacent half of the beam. The shearing strain at the left hand end of the beam is equal to half the whole load, and at the right end to minus the same quantity; the intensity decreasing uniformly from the ends to the centre, where it vanishes. This will be apparent by considering the force with which the sections marked A are driven down, in the three different cases represented by Figs. 4, 5 and 6.

If w represents the weight upon each unit of length, the shearing strain at a point at the distance x to the right of the centre of the beam, is $-wx$. In Fig. 7, let C be the centre of the beam, AB, uniformly loaded. The shearing strains at every point will be the ordinates of the line whose equation is

FIG. 4

$$y = -wx.$$

C being the orgin. Making $AD = -BE = \frac{wl}{2}$, l being the length of the beam, DE will be this line.

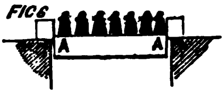
The dotted line dc gives the shearing strain in the same beam when uniformly loaded with a weight equal to $\frac{1}{2}$ w.

When a beam is but partially loaded, as in Fig. 8, (the beam itself

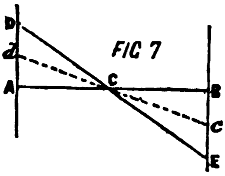
being supposed without weight), the weight is divided between the two supports in the inverse ratio of their distances from the centre of the load. The support A bearing the two weights next to it and $\frac{4}{7}$ths of the third, and the support B being the fourth weight, and $\frac{3}{7}$ths of the third. The shearing strains vanish at the point which thus divides the part of the load borne by one support from that borne by the other, and increase uniformly in intensity from that point to each end of the loaded portion; but the shearing strain is the same throughout the unloaded part of the beam, as it attains its full intensity at the end of the load, and there is no further weight to alter it. The strains will be given by the ordinates of a broken line, parallel to the line at strain for a fully loaded beam throughout the loaded portion, and parallel to the axis of abscissas through the unloaded part.

FIG 5.

FIG 6.



If l' denotes the length of the loaded portion, the weight borne by the loaded support is



$$\frac{l'\,w\left(l-\frac{l'}{2}\right)}{l}=l'\,w-\frac{l'^2w}{2l}$$

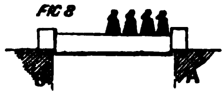
and by the unloaded

$$\frac{l'\,w\times\frac{l'}{2}}{l}=\frac{l'^2\,w}{2l}$$

Through the loaded part of the beam the shearing strains are the ordinates of the linear equation

$$y=\mp\frac{l'^2w}{2l}$$

FIG 8



the positive sign being used when the weight is next to the right hand support, and through the loaded portion by the ordinates of the lineal equation.

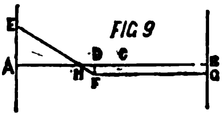
$$y=\pm\left(l'\,w-\frac{l'^2w}{2l}\right)-\left(x\pm\tfrac{1}{2}\,l\right)w=\mp\frac{(l-l')^2\,w}{2l}-wx$$

the positive signs being used when the weight is next to the left hand abutment.

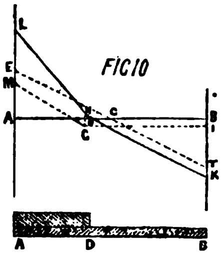
In Fig. 9 the beam is supposed to be loaded from A to D, and the broken line AFG is the line of strain.

When a beam is entirely loaded, but more heavily in one part

than another, the only practical case of a partial load, it may be regarded as uniformly loaded with a weight equal to that on the more lightly loaded portion, while a part of the beam bears also an additional load. The shearing strain produced by the united load will be at every point the sum of the strains produced by the two loads acting separately.



In Fig. 10, the beam AB is loaded uniformly with a weight equal to w for each unit of length, the part AD bearing an additional weight equal to w'. The strains caused by the uniform load are given by the line EF, and those caused by the partial load acting alone, by the broken line, MGI, while those resulting from the combined load are given by LHK, the ordinates LHK being at each point equal to the sum of the ordinates of the other two lines.



The equation of LH is:

$$y = -\frac{(l-l')^2 w'}{2l} - (w+w')\,x$$

and that of HK

$$y = -\frac{l'^2 w'}{2l} - wx\ .$$

HK is parallel to EI, and LH to a line passing through C, and corresponding to a uniform load equal $w + w'$. For the point of intersection H

$$x = l' - \frac{l}{2} \qquad y = \frac{l^2 w - l'^2 w}{2l} - l' w$$

To consider the effect of a moving load, let AB, Plate, Fig. 11, represent a beam upon which a load advances from A towards B. The shearing strains will then be indicated as follows:

Beam empty, by line DE.

Moving	load	covering	Aa,	by line	$a''\ a'\ a'''$
"	"	"	Ab,	"	$b''\ b'\ b'''$
"	"	"	Ac,	"	$c''\ c'\ c'''$
"	"	"	Ad,	"	$d''\ d'\ d'''$
"	"	"	Ae,	"	$e''\ e'\ e'''$
"	"	"	Af,	"	$f''\ f'\ f'''$
"	"	"	Ag,	"	$g''\ g'\ g'''$
"	"	"	Ah,	"	$h''\ h'\ h'''$
"	"	"	Ai,	"	$i''\ i'\ i'''$
"	"	"	*whole beam*	"	*FG.*

The points of intersection a' b' c' &c., lie upon a regular curve, DSG. As the load leaves the beam from the end, B, a similar series of changes takes place, the signs, however, being reversed, and the strains will be given by an arrangement of lines bounded by the curve, FS'E.

The bounding curves, DSG, and FS'E, give the limits of shearing strains under the action of a moving load. Between A and S it is always positive, and between S' and B always negative, while between S and S' it may be either, the point dividing the load borne by one support from that borne by the other shifting back and forth between these two points as the load advances.

The most intense strain at any point occurs when the load extends from that point to the more distant abutment; and the least intense strain, except between S and S', where the strains at times vanish, when the load extends from the given point to the nearer support.

In Fig. 10 we have for the ordinate of the point H:

$$y = \frac{l^2 w - l'^2 w}{2l} - l' w$$

which, if l' be made a variable, becomes the equation of the curve, DSG, and shows that curve to be a parabola. For the point S

$$y = \frac{l^2 w - l'^2 w'}{2l} - l' w = o$$

$$l' = \frac{\sqrt{w(w + w')} - w}{w'} l$$

The distance from S to the centre of the beam is—

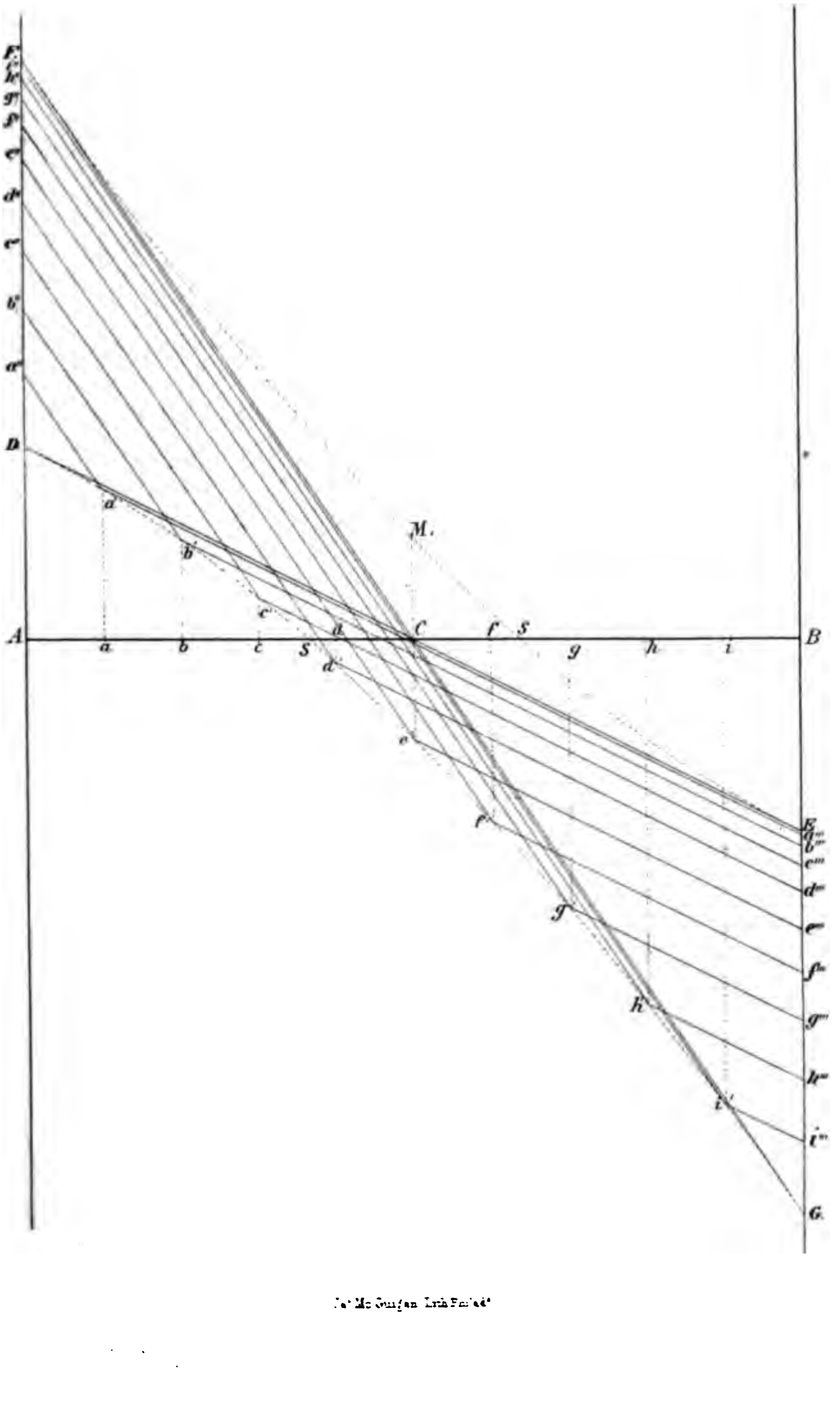
$$\tfrac{1}{2} l - l' = l \left(\tfrac{1}{2} - \frac{\sqrt{w(w + w')} - w}{w'} \right)$$

and from the centre of the beam to S' is the same At the centre of the beam, l' must be made equal to $\tfrac{1}{2} l$, which gives—

$$y = Ce' = -\frac{l w'}{8}$$

or the greatest possible shearing strain at the centre of the bridge is equal to one-eighth the total moving load. The strain at any other point may be easily found by simply constructing the curves. The members of the web should be proportioned accordingly.

A similar investigation might be made into the effects of a load of three different intensities; but as the strains would everywhere be less under the action of such a moving load, than under the


F
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action of a load of two different intensities corresponding to the greatest and least of the three, such an investigation is unnecessary.

(To be continued.)

INTER-OCEANIC COMMUNICATION BETWEEN THE ATLANTIC AND PACIFIC.

By D. S. Howard, C. E.

THE NICARAGUA ROUTE.

The natural advantages of this route were so apparent that every one wished to secure them to himself and his associates. Its early history shows that the first notice of it created a bitter controversy, which was kept up until another route, without any natural advantages, had been, by the sacrifice of an extravagant amount of money and human life, successfully established.

Nothing can flourish between belligerants. The victory is liable to be won by the party more skilled in strategy than the science of improving rivers and harbors, which was the case in this instance. But so much controversy as this route created, naturally raised the value of it in the eyes of the people of Nicaragua, so that now, after it has happened to fall into right hands for successful management, the government of Nicaragua increases their requirements for the privilege of improving their country, and lessen the exclusive privileges to be granted as equivalent. Thus the matter now stands.

The present Transit Company, with Mr. W. H. Webb as President, with abundant capital to do anything that may be advisable to be done, only ask a charter that will guard them against any vicious competition, such as the great natural advantages of this route might elicit.

The plan of improvement which the Company have adopted, has been so far tested already, that its success scarcely admits of a doubt.

They propose, first, to divert water enough from the Colorado outlet, which leaves the San Juan River twenty miles from the Carribean coast at Greytown.

This they will do by dredging at and below the junction of the Colorado. The declivity in the bed of the San Juan, below the junction, being about one and a-half feet per mile, renders it unnecessary to make the excavation more than four or five miles below

the junction with the Colorado. By making this about eight feet deep, in the lowest water, and about two hundred yards wide,—putting the material taken out into the Colorado,—will turn water enough down the lower San Juan to open the harbor at Greytown, and afford sufficient water for steamers drawing three or four feet at all seasons.

For this purpose, the Company have already provided a powerful dredging machine, capable of raising over three thousand (3,000) cubic yards per day of ten hours. This machine is provided with long spouts to run off the excavated material with water, for the purpose of dispensing with lighters, the expense and delay of towing to a place of deposit, &c., as much as possible, which was done with great success by a similar machine in the construction of the Corpus Christi Ship Channel, in Texas, in 1857–8. The same thing is now being done in the construction of the Suez Canal, mentioned in the June number of this *Journal*, page 378, by Mons. Lavalley, with the most gratifying results. This gentleman claims the above plan as his special invention. I do not wish to controvert this fact, presuming the idea was original with him, but, in justice to myself, I must say, that I made use of the same device in the construction of the Corpus Christi Ship Channel, as early as 1857, and successfully completed the work without the use of a lighter, except to hold up the outer end of the spouts. The idea was, then, original with me, whoever might have used it previously. I mention this fact, not to detract from the world-wide renown of Mons. Lavalley as an eminent engineer, but to claim the greater credit of preceding, in this instance, so successful an originator.

One great advantage of this route is its measurable availability, to begin with. Throughout the wet season, about half of the year, it is, in its natural state, a better route than any yet in use. It moreover affords important facilities for further improvement, so that every dollar properly expended upon it adds immediately to its value.

It is estimated that when three hundred thousand dollars shall have been expended on the the plans adopted by Mr. Webb, that this will successfully compete with any other route that can be made, short of a ship canal of the largest class.

These plans are so adapted to the natural advantages of this route, that improvement may go on until a first-class ship canal shall have been completed, without abandoning anything, at any time, as useless, that may have been done previously, so that, in the meantime, the navigation will have been improved by every

days' labor, and every dollar expended during the progress of the work, rendering loss of interest on capital actually expended, in case of any unforeseen delay, impossible at any time.

The great objection raised to investing money in the improvement of this river, is stated to be the "movable sands in the bottom." This sand can be excavated and transferred from the San Juan to the Colorado, at less cost than any other material. It is also more readily removed from the channel, by a judicious application of currents for scouring, than the more faultless materials. There has been so much time, talent, and money heretofore expended on rivers of this character, having a limited supply of water, with no resource for adding to or increasing the amount, with little or no success, that the improvement of this river is considered almost impossible by those who do not happen to know and appreciate the exceptional condition here existing, which is an abundant supply of water at all seasons, so situated as to be readily controlled.

The Rapids, on the upper river, may be improved for boats drawing four feet water, without the obstructions of locks and dams, by grading a sufficient channel to an easy ascent, adapted to the requirements of the boats to be used. This may be done at a trifling expense, compared with that of dams and locks.

With the Rapids and lower river and harbor improved at Greytown, the route is complete to within twelve miles of the Pacific. This part the Company propose to improve, by the construction of a railroad, from Virgin Bay, on the Lake, to Del Sur, on the Pacific.

From the increase of inter-oceanic trade, since the completion of the Panama Railroad, it is reasonable to predict the early necessity of a ship canal, in addition to these improvements. The feasibility of such a work has been made evident from a very exact survey by O. W. Childs, one of the most accurate and skilful engineers of his time. To show that his estimate was ample to provide for the full completion of the work, I will state that, during the six years he was Chief Engineer of the State of New York, he was never known to under-estimate any work in his charge.

His report on the Nicaragua Ship Canal was submitted to Cols. Albert and Turnbull, of the Topographical Bureau at Washington, who pronounced it ample for the purpose mentioned, and no person had attempted to criticise his items or question his amounts, until Rear Admiral Davis made his report on Inter-oceanic Communication, who seems to question it in a way which conveys the idea that a much larger sum than is named in the estimate will be

required. To make this appear, he mentions that "costly improvements, possessing the character of artificial harbors, will be necessary at the two points of departure from the Lake," &c. It is well known by every person that has been through the route, with any degree of discrimination in such matters, that no such structures are necessary.

The western departure from the Lake is perfectly protected by the form of the shore and Ometepe Island. The eastern departure is the outlet of the Lake, and is as perfect a harbor as can be made, well known to be perfectly safe for the native bungoes—large open boats navigating the Lake and river from Granada to Greytown at all seasons of the year.

Mr. Davis' report bears the marks of a questionable design, by some person or persons, on whom he depended too much for information concerning this route, who, probably, in the first instance, suggested the propriety of such a report to some influential member of Congress, for some private speculative purpose. I do not mean to cast any unworthy reflections upon Mr. Davis, who so worthily received the compliment from Congress of being selected to make this report; but the indications of some special design, in the manner of treating the description of this route in connection with others, are so plain to any person at all conversant with it, that it would be inconsistent with a proper regard for the true character and condition of the subject, to pass it unnoticed.

No country in the world can boast of a more salubrious, healthful climate, particularly along this route. There is no stagnant water, the river having a uniform descent of about one and a half feet per mile, between the Rapids, except seventeen miles immediately below the lower Rapids, which partakes of the nature of a deep, pure lake, rendering any accumulation of vegetable mud anywhere in the river-bed impossible, while all that may be deposited on the banks by freshets, is dissipated by the extraordinarily luxuriant growth of vegetation.

The delightful scenery along this route is not surpassed in any other uncultivated country. The luxuriant vegetation of various species of vines, and numerous varieties of parasites cover every tree in the first stages of decay, so that nothing is presented to the observer but the liveliest shades of living tropical vegetation on every side.

Lyons' Falls, N. Y., July 9th, 1868.

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 58.)

The Theory of Energy considers its Conservation, its Transformation and its Dissipation.

The *Conservation of Energy.*—The total amount of energy in the universe, or in any limited system which does not receive energy from without, or part with it to external matter, is invariable. Energy is, in other words, as indestructible as matter, and is neither created nor destroyed, but merely changes its form.

The *Transformation of Energy.*—By an extended induction, we find that any one form of energy may be transformed, wholly or partially, to an equivalent amount in another form. These transformations are, however, subject to limitations contained in the principle of

The *Dissipation of Energy.*—"No known natural process is exactly reversible, and whenever an attempt is made to transform or retransform energy by an imperfect process, part of the energy is necessarily transformed into heat and dissipated, so as to be incapable of further useful transformation. It therefore follows that as energy is constantly in a state of transformation, there is a constant degradation of energy to the final unavailable form of uniformly diffused heat; and this will go on as long as transformations occur, until the whole energy of the universe has taken this final form." See *N. Brit. Rev.*, May, 1864.

"There is consequently," says Prof. Thomson, "so far as we understand the present condition of the universe, a tendency towards a state in which all physical energy will be in the state of heat, and that heat so diffused that all matter will be at the same temperature; so that there will be an end of all physical phenomena."

Vast as this speculation may seem, it appears to be soundly based on experimental data, and to represent truly the present condition of the universe, so far as we know it. See Prof. Thomson "*On a Universal Tendency in Nature to the Dissipation of Mechanical Energy.*"—Proc. R. S. Edinb. and Phil. Mag., 1852.

The energy of a *moving* body is the work which it is capable of performing against a resistance before being brought to rest, and is equal to the force which must act on the body to move it from a state of rest to the given velocity. This force is measured by the product of the mass of the body into the height from which it must fall in order to acquire the given velocity; which is expressed thus:

$$\text{Energy} = \frac{M V^2}{2 g}$$

g representing as usual, the velocity acquired by a body at the end of the first second of its fall.

Energy may be of two kinds (1), *Kinetic energy*, or energy of motion, and (2) *Potential energy*, or energy of position or of condition. Thus, the energy of a ball shot vertically upward, is entirely kinetic at the moment of its discharge, while its energy is all potential, or one of position, when it has reached the summit of its flight and begins to descend. It is evident that the ball in descending, will gradually lose potential energy and gain kinetic energy (the sum of the two energies always remaining constant), and when it has reached the level from which it was discharged upward, its energy is again all kinetic, and equal to what it was when it began its upward flight. An oscillating pendulum is an instance where the energy is alternately kinetic and potential.

All the various forms of energy may be brought under two classes.

I. *Visible Energy*, or energy of visible motions and positions.

II. *Molecular Energy.*

Under class I. we have

A. Visible kinetic energy.

B. Potential energy of visible arrangement, as for examples, a head of water; a coiled spring; a raised weight.

Under class II.

C. The energy of electricity in motion.

D. The energy of radiant heat and light.

E. The kinetic energy of absorbed heat.

F. Molecular potential energy.

G. Potential energy caused by electrical separation.

H. Potential energy caused by chemical separation.

Now with regard to these various forms of energy, the principle of the conservation of energy asserts that for a body left to itself, or for the entire material universe, we must have

$$A + B + C + D + \&c., = \text{a constant quantity.}$$

On the other hand, the various terms of the left hand member of this equation must be considered as variable quantities, subject, however, to the above limitation, but capable of being transformed into one another according to certain laws.

Laws of the transmutations of energy.—The following are among the most important cases of transmutation of these energies into one another.

A into B, when a weight is projected upwards; into C, when a conductor revolves between the poles of a magnet. A is not transmuted directly into D; it is into E, F and G. A is not directly converted into H.

B can be converted into A, and through it into other forms of energy.

C can be transmuted into A, into E, into F, and into H.

D can be transmuted into E, into F, and into H.

E and F is converted into A and into B, in the action of any heat-engine; into C, into D; into G when tourmalines are heated; and into H.

G can be converted into A and into C.

H can be transmuted into C; into E, into F, and into G. (See Elementary Treatise on Heat, by Balfour Stewart, Oxford, 1866.)

Sources of Energy.—The energy available for the production of mechanical work is almost entirely potential, and consists of

Potential forms of Energy.

1. Energy of Fuel.
2. Energy of Food.
3. Energy of Ordinary Water-Power.
4. Energy of Tidal Water-Power.
5. Energy of Chemical separation implied in native sulphur, native metals, free oxygen, &c.

Of Kinetic forms of Energy.

6. Energy of Winds and Ocean Currents.
7. Energy of Direct Rays of the Sun.
8. Energy of Volcanoes, Hot Springs and Internal Heat of the Earth.

"The immediate sources of these supplies of energy are four:—

I. Primordial Potential Energy of Chemical Affinity, which probably still exists in native metals, native sulphur, &c., but whose amount, at all events near the *surface* of the earth, is now very small.

II. Solar Radiation. III. The Earth's rotation about its axis.

IV. The Internal Heat of the Earth.

Thus, as regards (1) our supplies of fuel for heat-engines are, as was long ago remarked by Herschel and Stephenson, mainly due to solar radiation. Our coal is merely the result of transformation in vegetables, of solar energy into potential energy of chemical affinity. So, on a small scale, are diamond, amber and other combustible products of primeval vegetation. As Prof. Thomson remarks, wood fires give us heat and light which have been got from the sun a few years ago. Our coal fires and gas lamps bring out, for our present comfort, heat and light of a primeval sun, which have lain dormant as a potential energy, beneath seas and mountains for countless ages.

Though (II) thus accounts for the greater part of our store of energy, (I) must also be admitted, though to a very subordinate place.

As to (2), the food of all animals is vegetable or animal, and therefore ultimately vegetable. This energy, then, depends almost entirely on (II). This, also, was stated long ago by Herschel.

Ordinary water-power (3) is the result of evaporation, the diffusion and convection of vapor, and its subsequent condensation at a higher level. It also is mainly due to (II).

Tidal water-power (4), although not yet much used, is capable, if properly applied, of giving valuable supplies of energy. As the water is lifted by the attraction of the sun and moon, it may be secured by proper contrivances at its higher level, and then becomes an available supply of energy when the tide has fallen again. Any such supply is, however, abstracted from the energy of the earth's rotation (III). This was recognized by Kant; Mayer also and J. Thomson showed that the ebb and flow of the tides being due to the earth's revolving on her axis under the moon's attraction, the energy of the tides is really taken from the energy of the earth's revolution; part of which is thus ultimately dissipated in the heat of friction caused by the tides. The general tendency of tides on the surface of a planet is to retard its rotation till it turns always the same face to the tide-producing body; and it is probable that the remarkable fact that satellites generally turn the same face to

their primary, is to be accounted for by tides produced by the primary in the satellite while it was yet in a molten state.

Winds and ocean currents (6), both employed in navigation, and the former in driving machinery, are, like (3), direct transformations of solar radiation (II).

As to (8), which is due to (IV), no application to useful mechanical purposes has yet been attempted.

We must next very briefly consider the origin of these causes, with the exception of (I), which is of course primary. Laplace, Mayer and Helmholtz come to our assistance, and suggest as the initial form of the energy of the universe, the potential energy of gravitation of matter irregularly diffused through infinite space. By simple calculations it is easy to see that, if the matter in the solar system had been originally spread through a space enclosing the orbit of Neptune, the falling together of its parts into separate agglomerations, such as the sun and planets, would far more than account for all the energy they now possess in the forms of heat and orbital and axial revolutions.

The sun still retains so much potential energy among its parts, that the mere contraction by cooling must be sufficient (on account of the diminution of potential energy) to maintain the present rate of radiation for ages to come. Moreover, the capacity of the sun's mass for heat, on account especially, of the enormous pressure to which it is exposed, is so great that (at the least and most favorable assumption) from 7,000 to 8,000 years must elapse, at the present rate of expenditure, before the temperature of the whole is lowered one degree centigrade, although the amount of solar heat received by the earth in one year is so enormous that it would liquify a layer of ice 100 feet thick, covering the whole surface of the earth, and if we bear in mind that the solar heat which reaches the earth in any time is only $\frac{1}{2300000000}$ of the heat which leaves the sun, we may obtain some idea of the immense heating power of the radiation from our luminary.*

It thus appears that if we except tidal-power, the sun's rays are the ultimate source of the available forms of energy with which we are surrounded.†

* If the entire solar radiation were employed in dissolving a layer of ice, enclosing the sun, it would dissolye a stratum 10½ miles thick in a day.

† The sketch we here give of the *Sources of Energy*, is taken almost entirely from an article on "Energy,' in the N. Brit. Rev., May, 1864.

We see, from the above exposition, that "Philosophers have extended their ideas of quantity from matter to energy, and thus has arisen the new science of *Energetics*, or the quantitative study of the transformations of energy (as chemistry is the quantitative study of the transformations of matter), comprehending and uniting all the different branches of physical science."

Efficiency of Heat-Engines.—After Joule had determined the mechanical equivalent of heat, engineers had the means of testing the actual efficiency of heat-engines.

If the number of thermal units produced by the combustion of one pound of a given kind of fuel, be multiplied by Joule's unit, 772 foot-pounds, the result is the *total heat of combustion* of the given fuel expressed in foot-pounds. This quantity ranges between 5,000,000 and 12,000,000 foot-pounds. But in the best existing steam-engines, it is found that on an average only about $\frac{1}{8}$ of the mechanical value of the heat produced by the fuel burning in the furnace, is obtained as useful mechanical effect, the remaining $\frac{7}{8}$ being wholly lost.

To understand the cause of this great loss, it is to be remembered that in every heat-engine the heat of the expansible fluid—which is the medium by which the heat of the fuel is transformed into the motion of the engine—disappears *as heat* by the exact equivalent, expressed in Joule's units, of the motion produced. Therefore the greater the fall in heat in the vapor, which, in expanding, cools and gives up its heat as motion, so will be the efficacy of the engine. Just as in a head of water, where the greater the difference between the higher and lower level, the greater the power obtained. But in the steam-engine we are obliged to obtain our power from the fall in temperature of the steam, which takes place in its expansion, so that in a steam-engine the power obtained is measured by the difference of temperature between the boiler and condenser, and *not* by the difference between the temperature of the furnace and condenser. Now, in the furnace the temperature is about 3,000 degrees above that of the atmosphere, while the temperature of the boiler is only about 200 degrees in excess of that of the condenser; therefore it is evident that the larger fall in temperature taking place between the furnace and the steam, the heat is lost or at least not utilized.

In a *perfect engine* the steam would enter the cylinder at the temperature of the furnace, and expand down until it had given up all its heat as motion to the piston, and would then enter the condenser

at the temperature of the atmosphere; indeed, such an engine would require no condenser, for the steam would condense itself as the heat disappeared in its transmutation into motion.

We will conclude this sketch on the subject of Energy, with a concise statement in reference to the efficiency of heat-engines, taken from Prof. Rankine; referring the reader who desires further information on this important and interesting subject to the works given below.

"The total heat produced in the furnace is expended, in any given engine, in producing the following effects, whose sum is equal to the heat so expended:—

1. The *waste heat of the furnace*, being from 0·1 to 0·6 of the total heat, according to the construction of the furnace and the skill with which the combustion is regulated.

2. The *necessarily-rejected heat of the engine*, being the excess of the whole heat communicated to the working fluid by each pound of fuel burned, above the portion of that heat which permanently disappears, being replaced by mechanical energy.

3. The *heat wasted by the engine*, whether by conduction or by non-fulfilment of the conditions of maximum efficiency.

4. The *useless work of the engine*, employed in overcoming friction and other prejudicial resistances.

5. The *useful work*. The efficiency of a heat-engine is improved by diminishing as far as possible, the first four of those effects, so as to increase the fifth.

"It appears, then, that the efficiency of a heat-engine is the product of three factors, viz: I. The *efficiency of the furnace*, being the ratio which the heat transferred to the working fluid bears to the total heat of combustion; II. The *efficiency of the fluid*, being the fraction of the heat received by it, which is transformed into mechanical energy; and III., The *efficiency of the mechanism*, being the fraction of that energy which is available for driving machines."

From the above discussion, we see immediately that by superheating the steam before it reaches the cylinder, we obtain a greater range of temperature for the steam to fall through in expanding, and thus render efficacious yet more of the heat of the furnace.

List of Works on the Conservation of Force and Thermodynamics.

The Correlation and Conservation of Forces; a collection of the papers of *Mayer*, *Helmholtz*, *Faraday*, *Grove*, *Liebig* and *Carpenter*. Edited by Dr. Edward L. Youmans, N. Y., 1865.

Joule.—On the Calorific Effects of Magneto-Electricity, and on the Mechanical Value of Heat. Phil. Mag., Vol. XXIII., 1843.

On the Changes of Temperature produced by the Rarefaction and Condensation of Air. Phil. Mag., May, 1845.

On the Mechanical Equivalent of Heat. Phil. Trans., 1850.

On some Thermodynamic Properties of Solids. Phil. Trans., 1859.

On the Thermal Effects of Compressing Fluids. Phil. Trans., 1859.

Clausius.—The Mechanical Theory of Heat, with its applications to the Steam Engine and to the Physical Properties of Bodies. Edited by T. A. Hirst, with an Introduction by Prof. Tyndall. London, 1867.

Thomson (William).—An Account of Carnot's Theory of the Motive Power of Heat. Trans. R. S., Edinb., 1849.

On the Dynamical Theory of Heat. Trans. R. S., Edinb., 1852.

Thomson and *Joule.*—On the Thermal Effects of Fluids in Motion. Phil. Trans., 1853.

On the Changes of Temperature experienced by Bodies moving through Air. Phil. Trans., 1860.

Rankine.—The Steam Engine and other Prime Movers. London, 1859.

Verdet.—Exposé de la Théorie Méchanique de la Chaleur. Paris, 1863.

Hirn.—Exposition Analytique et Expérimentale de la Théorie Méchanique de la Chaleur. Paris, 1865.

Saint—Robert.—Principes de Thermodynamique. Turin, 1865.

Bacon.—Novum Organum, De Formâ Calidi, book 2, aph. 20.

"Now from this our first vintage it follows, that the form or true definition of heat (considered relatively to the universe and not to the sense) is briefly thus:—Heat is a motion, expansive, restrained, and acting in its strife upon the smaller particles of bodies. But the expansion is thus modified: while it expands all ways, it has at the same time an inclination upwards. And the struggle in the particles is modified also; it is not sluggish, but hurried and with violence."

Locke.—"Heat is a very brisk agitation of the insensible parts of the object, which produce in us that sensation from whence we denominate the object hot; so what in our sensation is *heat*, in the object is nothing but *motion*."

Rumford.—*Trans. R. S. Lond.*, 1798. Rumford placed a cannon in a water-tight box, so that it could rotate against a blunt borer firmly pressed against the bottom of its chamber. The box was filled with water of a temperature of 60° F., and the cannon set in rotation by the power of horses.

"The result of this beautiful experiment was very striking, and the pleasure it afforded me amply repaid me for all the trouble I had had in contriving and

arranging the complicated machinery used in making it. The cylinder had been in motion but a short time, when I perceived, by putting my hand into the water, and touching the outside of the cylinder, that heat was generated.

"At the end of an hour the fluid, which weighed 18·77 lbs., or 2¼ gallons, had its temperature raised 47 degrees, being now 107 degrees.

"In thirty minutes more, or one hour and thirty minutes after the machinery had been set in motion, the heat of the water was 142 degrees.

"At the end of two hours from the beginning, the temperature was 178 degrees.

"At two hours and twenty minutes it was 200 degrees, and at two hours and thirty minutes it *actually boiled.*

"From the results of my computations, it appears that the quantity of heat produced equably, or in a continuous stream, if I may use the expression, by the friction of the blunt steel borer against the bottom of the hollow metallic cylinder, was *greater* than that produced in the combustion of *nine wax candles*, each ¾ inch in diameter, all burning together with clear bright flames.

"One horse would have been equal to the work performed, though two were actually employed. Heat may thus be produced merely by the strength of a horse, and, in case of necessity, this heat might be used in cooking victuals. But no circumstances could be imagined in which this method of procuring heat would be advantageous; for more heat might be obtained by using the fodder, necessary for the support of a horse, as fuel.

* * * * * "It is hardly necessary to add, that anything which any *insulated* body or system of bodies can continue to furnish *without limitation*, cannot possibly be a *material substance;* and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in those experiments, except *motion*."

Davy.—First scientific memoir, entitled "On Heat, Light, and the Combinations of Light." Works Vol. II.

"*Experiment.*—I procured two parallelopipedons of ice, of the temperature of 29°, six inches long, two wide, and two-thirds of an inch thick; they were fastened by wires, to two bars of iron. By a peculiar mechanism, their surfaces were placed in contact, and kept in a continued and most violent friction for some minutes. They were almost entirely converted into water, which water was collected, and its temperature ascertained to be 35°, after remaining in an atmosphere of a lower temperature for some minutes. The fusion took place only at the plane of contact of the two pieces of ice, and no bodies were in friction but ice.

"From this experiment it is evident that ice by friction is converted into water and according to the supposition, its capacity is diminished; but it is a well-known fact that the capacity of water for heat is much greater than that of ice; and ice must have an absolute quantity of heat added to it before it can be converted into water. Friction consequently does not diminish the capacity of bodies for heat.

* * * * * * *

"Now a motion or vibration of the corpuscules of bodies must be necessarily generated by friction and percussion. Therefore we may reasonably conclude that this motion or vibration is heat, or the repulsive power.

Davy in his *Chemical Philosophy*, p. 95, says:

"* * * * The immediate cause of the phenomena heat, then, is motion, and the laws of its communication are precisely the same as the laws of the communication of motion."

A process similar to the above classical experiment of Davy, has from time immemorial been used by savage nations in obtaining fire by means of friction: not by *rubbing* together sticks, as usually stated, for no one could thus produce ignition, but by *whirling* rapidly, a pointed rod against a wooden block, by means of an arrangement similar to the watchmaker's bow and drill. It is worthy of remark that this apparatus has everywhere the same form, whether used by the islanders of the Pacific or by the aborigines of our own country. One of these instruments can be seen in the State Cabinet of Natural History of New York.

Henry (Dr. Joseph).—Meteorology—Patent Office Report for 1857.

On Acoustics applied to Public Buildings—Smithsonian Report, 1856, p. 228.

"The tuning-fork was next placed upon a cube of India rubber, and this upon the marble slab. The sound emitted by this arrangement was scarcely greater than in the case of the tuning-fork suspended from the cambric thread, and from the analogy of the previous experiments, we might at first thought suppose the time of duration would be great; but this was not the case. The vibrations continued only about forty seconds. The question may here be asked, what became of the impulses lost by the tuning-fork? They were neither transmitted through the India rubber nor given off to the air in form of sound, but were probably expended in producing a change in the matter of the India rubber, or were converted into heat, or both. Though the inquiry did not fall strictly within the line of this series of investigations, yet it was of so interesting a character in a physical point of view to determine whether heat was actually produced, that the following experiment was made.

* * * "And the point of a compound wire, formed of copper and iron, was thrust into the substance of the rubber, while the other ends of the wire were connected with a delicate galvanometer. The needle was suffered to come to rest, the tuning-fork was then vibrated, and its impulses transmitted to the rubber. A very perceptible increase of temperature was the result. The needle moved through an arc of from one to two and a half degrees. The experiment was varied, and many times repeated; the motions of the needle were always in the same direction, namely, in that which was produced when the point of the compound wire was heated by momentary contact with the fingers. The amount of heat generated in this way is, however, small, and indeed, in all cases in which it is generated by mechanical means, the amount evolved appears very small in comparison with the labor expended in producing it."

Leibnitz.—"The *force* of a moving body is proportional to the square of its velocity, or to the height to which it would rise against gravity."

Wollaston.—Bakerian Lecture on the Force of Percussion. Phil. Trans., Vol. XCVI., 1806.

"In short, whether we are considering the sources of extended exertion or of accumulated energy, whether we compare the accumulated forces themselves by their gradual or by their sudden effects, the idea of mechanic force in practice is always the same, and is proportional to the *space* through which any moving force is exerted or overcome, or to the *square* of the velocity of a body in which such force is accumulated."

Tyndall.—Heat considered as a Mode of Motion. New York, 1863.

I need hardly refer the reader to this charming exposition of Prof. Tyndall; who, by his enthusiasm and vividness of illustration, has rendered his subject so popular that his work is, in this country, in the library of nearly every man of culture.

(To be continued.)

NITRO-GLYCERINE: ITS CLAIMS AS A NEW INDUSTRIAL AGENT.

BY JOHN MAYER, F. C. S.

(Concluded from page 45.)

Many interesting observations were also made on nitro-glycerine, both in the protected and explosive states, by a Royal Commission, appointed from the Engineer Corps of the Prussian army. They were made in the year 1866, at Glogau, in Silesia. One or two of the experiments may be mentioned. Protected nitro-glycerine was poured into a tin vessel, seven inches square, and twelve inches high, and fired at with a breech-loading musket, from a distance of seventy feet, or thereabouts. At the first trial common, and at the second explosive, cartridges were used. When the ball struck there was no explosion in either case. "In order to ascertain its character of safety during transport, two conveyances of inexplosive nitro-glycerine were undertaken. The distance of the first tour, *via* Bauschwitz and Gurken, was about one German mile. The carts passed over macadamized roads, good and bad, and returned in about one hour. A tin bottle, containing three and a half ounces of protected nitro-glycerine, was put into an old powder-box, and secured in such a manner as to admit of its moving backwards and forwards without falling down; nor was it entirely filled. The powder-box was attached to the hind axle-tree of a wagon with racks. Every pace of the horses was tried without any explosion taking place. At the second trial four horses were put to an Austrian ammunition wagon. One pound of inexplosive nitro-glycerine was put into this wagon, in a tin bottle, one-third empty, and the latter secured so as to allow it to move to and fro without falling down. This trip was somewhat longer, the cart going over about two German miles of ground. The cart was driven intentionally over the very worst parts of the road, and at the most rapid pace. On the road the bottle was inspected and was found to leak at the mouth. By this means, some blasting liquid had accumulated at the bottom of the wagon, which by evaporation must have become explosive. But, as even explosive nitro-glycerine does not explode on wood, when struck ever so hard with a hammer, the trial was continued. In order to

ascertain finally whether a prolonged uniform movement leads to a result different to that of violent shocks, the cart was driven from Bauschwitz to the scene of the experiments, about half a German mile, half of the road stone pavement, in a sharp but regular trot. No explosion took place."

The transformation of protected into ordinary nitro-glycerine is effected by thoroughly agitating it with water, and allowing the mixture to settle for a short while. By this means the water dissolves out the methyl-alcohol, and the mixture of spirit and water readily rises to the surface, in virtue of its low specific gravity, and can be removed by means of a siphon, or by simply pouring it off. The blasting liquid is now ready for use. It would seem that the methyl-alcohol is by this means separated very readily from the nitro-glycerine held in solution by it. If protected blasting liquid be kept in a closed vessel, it will remain in that state for an indefinite period of time, and ready at any moment to be reduced or rendered fit for action; if, however, it be exposed in an open vessel, it will regain its explosiveness, in periods of time proportionate to the amount or degree of exposure. In the experiments, for instance, which were instituted by the Prussian Military Commission, it was observed that protected nitro-glycerine, exposed to the air in an open glass, only acquired explosiveness on the twenty-first day, although it was tried every second or third day; and such protected liquid, after being exposed in an open bottle with a narrow neck for twenty-one days, exhibited no tendency to explosion even then,—thus showing that comparative confinement of the liquid very greatly retards the evaporation of the solvent and protecting wood-spirit.

As an explosive capable of being practically used, nitro-glycerine is quite an exceptional substance, from the circumstance of its being a *liquid* compound. There are other liquid explosives,—as the so-called chloride of nitrogen, for instance,—but nobody has ever yet succeeded in practically applying them, or even ventured to prepare any of them in large quantity. The force exerted by nitro-glycerine, during an explosion, is truly marvellous; indeed, no correct conception can be formed of it by any person who has not himself experimented with it, or has, at all events, seen the experiments performed. Weight for weight, the new explosive is ten times more powerful than gunpowder. The extraordinary mechanical or eruptive power which it exerts is partly owing to the fact that there is no solid residue attending the explosion, and that the enormous pressure exerted by the resulting gases is due to the great rapidity of the explosion. The rocks being blasted have not time enough permitted them to effect any sensible cooling and condensing of the vapors. In fissured rocks this rapidity of explosion is of immense consequence; it is so very great that the tamping employed in blasting operations, is in many cases not ejected from the bore-holes, although—by preference—it is almost invariably quite

loose, consisting of sand, slate-dust, or other finely divided solid matter, or even ordinary water.

Hard tamping is of comparatively little use, owing to another very curious property possessed by nitro-glycerine, namely, that of "striking down," as it has been called, or of exerting its explosive force—unlike gunpowder—almost entirely in a downward direction. This circumstance is intimately connected with the explosion on board, and ultimate destruction of, the steamship 'European' at Aspinwall. The nitro-glycerine taken by that vessel from Liverpool was placed in the very bottom of the hold, owing to its being shipped as a liquid. There is not room here to discuss all the *pros* and *cons* of that catastrophe; but one or two facts may be mentioned, as they have great scientific and practical interest, and some of them, although brought out at the Liverpool trial last summer and made public, have been misinterpreted. It is known that, besides the seventy-two 28lb. cases of nitro-glycerine, there were some 20,000 percussion caps and other combustible substances on board. It is also known that there were three explosions, the first being very loud, and occurring about twenty minutes before the second, which was not nearly so loud, and the the third and last occurring *after the vessel had taken fire*, and had been for some time out at sea, where she had been towed by another steamer, and where she continued to burn, and eventually went down. The nitro-glycerine confined in the hold of a large iron steamer in such a warm climate, would necessarily be in a somewhat sensitive state. The spontaneous combustion theory set up at the Liverpool trial, and supported by Professors Abel and Roscoe, is not necessary to account for the results. The first explosion was certainly due to nitro-glycerine, a case of which was being hoisted up by a steam crane, and with such rapidity that when near the deck it struck against a beam and immediately exploded, when it was observed that two iron plates were blown off the top of the vessel on the port side and near the stern. There seems to be no room for doubting that the last explosion was also caused by nitro-glycerine, when the loudness of that explosion—it was louder than the second—is borne in mind, as also the intense heat of the burning ship, the position occupied by the remaining seventy-one cases of the liquid, the "striking down" character of an explosion of nitro-glycerine, and the fact that the said explosion caused the ship to go down. That it did not seem so loud as the first explosion, is accounted for by the circumstance that the ship was not then lying at the wharf, but was some distance out at sea, and by the fact, also, that the nitro-glycerine was at the very bottom of the hold, at least ten or fifteen feet below the surface of the water.

Had we space at command, it would be profitable to discuss the facts and suppositions connected with the Newcastle explosion, as that occurrence is invested with a great amount of interest. The

evidence at the coroner's inquest—as at the Liverpool trial—brought forth the usual theory of spontaneous decomposition, supported by the stock arguments. As we happen to know something of the history of the Newcastle nitro-glycerine, we may oppose a few facts to the fiction which the Newcastle coroner was compelled to listen to. To do so may possibly disabuse the minds of some persons of the prejudices acquired by the untoward event of December last. The nitro-glycerine in question was manufactured at Hamburg in the usual way, mixed with methyl-alcohol, and shipped as inexplosive blasting liquid, at the commencement of the winter 1866–7, on board a vessel which, on account of an accident, had to put into Harwich, where the cargo was received into two lighters, and remained about two months exposed to the severest weather of the season. One of the cases was opened at Harwich, in order to get a sample, but that was found to be an impossibility, as the contained nitro-glycerine was a perfectly solid ice-like mass. The weather had apparently destroyed the effect of the methyl-alcohol. When the substance was conveyed to Carnarvon, part of it was washed with water in the usual way, to remove the alcohol, as if it were still protected. But that was found to be unnecessary. The slate quarrymen fired it with gunpowder without any difficulty, and it was evident that the effect of the alcohol, if not entirely destroyed was nearly so. Twenty-four of the cases—6 cwt.—were sent into the Newcastle district in July last. A large portion of it, as is now well known, was stored in the town of Newcastle, in contravention of the provisions of the "Carriage and Deposit of Dangerous Goods Act, 1866." At the fatal Town Moor, three of the tin cases, the tops of which were strongly soldered down, were forcibly opened by means of a spade, and found to contain a quantity of solid nitro-glycerine. In this state, practical men know it to be more difficult to explode than when in the liquid state; but that it resisted such violent treatment is almost inconceivable, and that Sub-Inspector Wallace is still living is little short of a miracle. Is it possible that any sane person can believe that the crystallized nitro-glycerine after such a rough career and such violent usage could explode spontaneously? that it was so sensitive that the simple slipping or friction of one piece upon another brought about the fatal explosion? We sincerely hope not.

That nitro-glycerine has properties of peculiar value in blasting operations may be inferred from the following facts:—

The first and most successful company formed for the manufacture of the substance, is one formed at Stockholm, towards the end of the year 1864, and the shareholders in which are *all Swedish miners*, with the exception of one who is the director of the Stockholm Private Bank. The shares are much in request, but they are not in the market, and cannot be had, and the dividends are greater than the directors care to tell. The rapidity with which the Swe-

dish miners took to the use of the new blasting agent is most extraordinary. The great tunnel of the Central Railway through Stockholm was blasted throughout with nitro-glycerine made by that company. A stupid accident occurred—not an explosion of the blasting liquid—which frightened the authorities so much that a royal order was issued that no more than two pounds of nitro-glycerine should be stored in one place within the city; but the workmen declared, one and all, that they would resign rather than work again with gunpowder for the same pay. For a few days, the royal order remained in force, but it was then cancelled by dint of necessity, and the work of the tunnel proceeded to completion—the greatest underground work executed by the new blasting agent. Mr. Eric Unge, the chief engineer and managing director, speaks very highly of the advantages of using nitro-glycerine, including amongst them the saving of 23 per cent. on the cost of blasting, and 87 per cent. greater speed than with the use of gunpowder.

In the largest slate quarries of North Wales—some of them of immense extent—a larger amount of money is spent yearly on nitro-glycerine than on gunpowder for blasting purposes; and in many cases the men make their bargains dependent on the quarry proprietors, undertaking to guarantee a supply of nitro-glycerine. Tons of this substance are used annually in the Welsh slate quarries, and yet accidents from its use, or rather its abuse, are almost never heard of. At the Penrhyn and Dinorwic quarries, one quarter of a ton per month is used. Mr. Parry, the manager of the Dinorwic quarries, was recently asked about the danger of using nitro-glycerine as a blasting agent. He said they never had an accident with it, while the accidents from gunpowder were so numerous during the past year, that he really could not tell how many there had been.

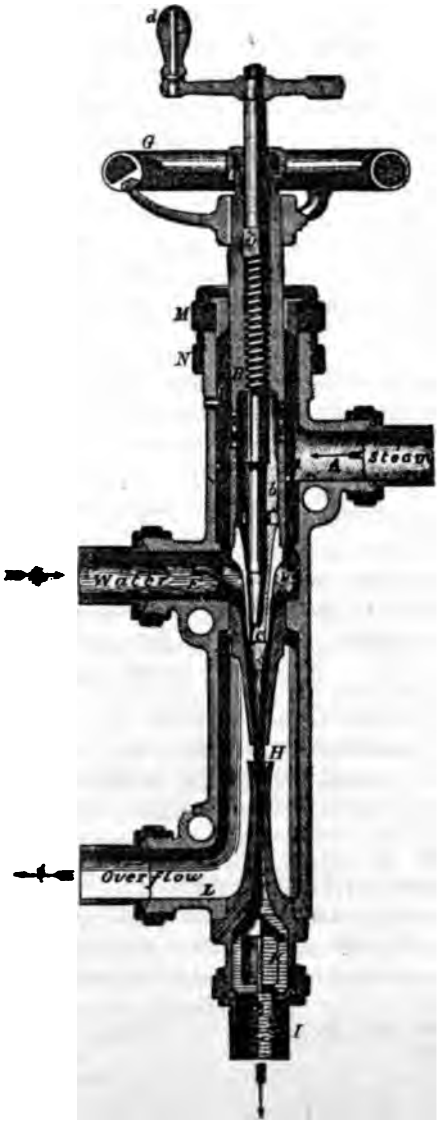
These are only samples of scores of facts which might be quoted in respect of the safety, the remarkable properties, and extensive use now attained by nitro-glycerine. In concluding, we may use the language of one of our correspondents, who favors us with his experience as a practical man. He says:—"Miners may have dreamed of a blasting material ten times as strong as gunpowder, exploding with such velocity as to need no tamping, unaffected by water, blasting seamy as well as the hardest and most solid rock, and leaving no smoke; but surely in this substance the very properties most needed are realized to such an extent as to appear utopian or extravagant to all those who have not tried it for themselves. Whatever its drawbacks may be, nitro-glycerine certainly deserves a fair and liberal investigation. Nature and science have placed at our command one of the most powerful agents ever sent forth from their united laboratory; neighboring nations have learned to tame its somewhat rebellious nature, and why should not we follow the example which they have set us?"

THE GIFFARD INJECTOR.

(Continued from page 58.)

Having thus considered the theory of this apparatus, we will now describe its actual structure and operation, and first in its original form.

Fig. 3.



Referring to the cut, Fig. 3, which exhibits a section of the apparatus as formerly manufactured by the Messrs. Sellers, of this city, we see, first, a pipe, A, by which steam is admitted from the boiler, and passing through orifices cut between the threads of the hollow screw, B*b*, enters the space, *b*, from which it passes out by the conical nozzle, C, its flow being regulated by adjustment of the conical rod or plug, controlled by the handle, *d*, and screw-thread, OB. At E is another pipe supplying water to the annular space about C, from a reservoir, not more than 5 feet below, from which it may pass out by the conical nozzle, FH, its amount being regulated by the position of the tube or nozzle, C, which is controlled by the hand-wheel, G, and screw-thread. Opposite and in line with the nozzle, FH, is a conical tube, having a valve, K, at its further end, from which the pipe leads to the water space of the boiler. Around the two last-named conical tubes, or nozzles, is

a casing, which serves to connect the parts, and has an outlet or overflow, L, to be noticed presently.

The operation of this instrument is as follows: By almost closing the annular opening around the nozzle C, and opening the steam-cock to the boiler so as to allow a little steam to pass out of the nozzle, C, we produce a partial vacuum in EF, by which water is drawn up into, and delivered from, the nozzle into the space around H, from which it escapes by the overflow, L. More steam and water being let on, the condensed steam and water uniting in the combining tube, F, acquire such velocity as to enter HK, and opening the valve, pass into the boiler.

When the supply of steam and water is properly adjusted, all escape from the overflow will cease.

If the water supply is in excess, some water will escape by this outlet, so indicating a waste of material and force; while, if the steam is in excess, a partial vacuum and indraft of air will occur, thus showing that the apparatus is not performing its maximum duty in forcing water into the boiler.

The amount of water which can be driven into the boiler will vary with the pressure, and, therefore, under changing conditions of pressure, frequent adjustment will be required to keep the apparatus in operation and to obtain a maximum effect. The reason of this variation in effectiveness with change of pressure will be evident, if we refer to our previous explanation on p. 57. It was there shown that, in one view, the efficiency of this instrument depended upon the contraction of a large volume of steam into a small volume of water, whereby the pressure exerted upon a large area of exit was concentrated upon a smaller one of entrance. Now it is clear, that the lower the pressure in the boiler the greater will be the volume of the escaping steam, and, therefore, the greater the amount of its concentration in condensing. By an increase of pressure, it is true, we increase the velocity of the escaping steam; but we also, by the same means, increase the resistance or pressure opposing the entrance of the water into the boiler.

It therefore appears, that from the theoretical considerations involved in the explanation given before, we might anticipate what we find in practice to be the fact, namely, that the largest amount of water, in proportion to the steam escaping, can be injected with the lower pressure.

Of course, with the greater pressure, the *amount* of steam passing out is greatly increased, and thus the actual amount injected is

somewhat increased, while what we may call the "duty" of the steam employed, falls off. Thus a No. 2 Injector, with 30 pounds of steam pressure, throws 9·7 cubic feet water per hour, and with 150 pounds, throws 18·1. The amount of water discharged being less than double, while the pressure is increased five times.

In locomotive boilers, and others, having a small water and steam capacity, compared with their heating surface, the necessity for re-adjustment of the water supply by the attendant, indicated and discussed above, becomes a serious inconvenience, especially when, as in the case cited, great and frequent changes occur in the steam pressure.

To obviate this difficulty, and to render the apparatus self-adjusting, with reference to the water supply, so that it would always be giving a maximum delivery, under changing conditions of pressure, has long been desired, and has at last been accomplished in the apparatus devised by Mr. William Sellers; which we shall now proceed to describe.

It was long known, that when the supply of water was somewhat less than that which the injector was capable of throwing at the time, a partial vacuum was formed in the chamber surrounding the nozzles, so that if the hand were held against the waste-pipe, an indraft would be sensible. Here then, clearly, was a force which might, in some way, be applied in regulating the water supply in one direction, that is, by increasing it when insufficient. This alone, however, would not answer; an opposite force must also be supplied, by which the inflow of water, when too great, might be checked.

The existence of an action by which such a force might be developed, was discovered and demonstrated by Mr. Sellers, in the following manner:

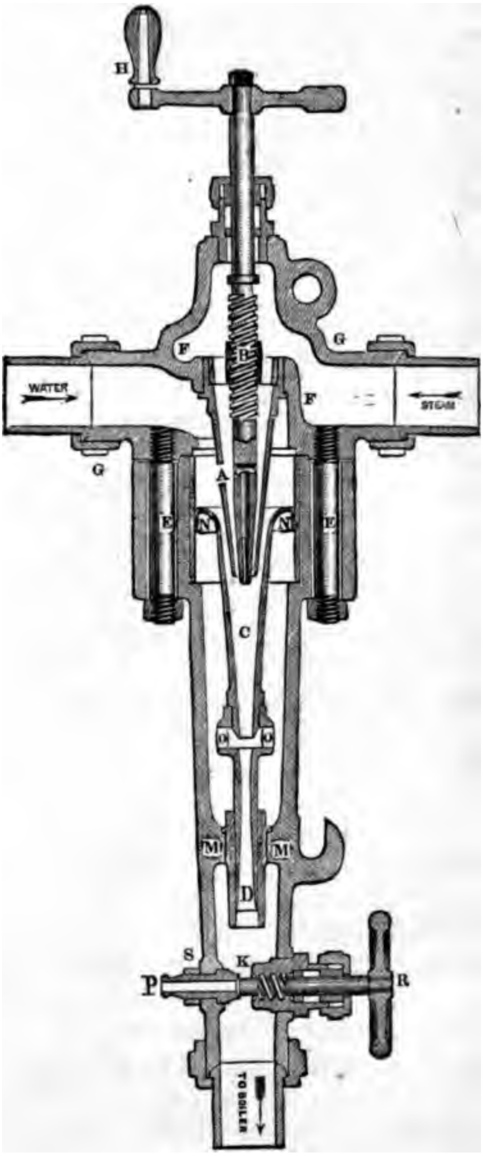
An Injector was provided with a pressure-gauge, in connection with a space around the discharging and receiving pipes, and with a stop-valve upon the waste-pipe.

The instrument being so adjusted that its water supply was in excess, and a quantity of water, therefore, discharging from the waste-pipe, the stop-valve was then partially closed, until the excess of water collected in the chamber and produced pressure on the gauge, when it was found that the Injector would continue to act, and to force water into the boiler even when the pressure in the chamber nearly equaled that of the boiler.

Here, then, was the force required, and we will proceed to describe the arrangement of apparatus by which it was caused to develop, with ease and certainty, the desired effect.

A glance at the accompanying section will show how vital an alteration the instrument underwent in the new modification.

Fig. 4.



The outer shell or case consists of two parts, united by bolts, E E. The part G G is provided with two inlets, the one for steam, the other for water, as shown in the cut, the two being separated by the plate, F F, in the centre of which is at-attached a nozzle, A, for the steam jet. The amount of steam which may be discharged by this nozzle, is regulated by the tapered plug which is operated by the screw, B, and exterior handle, H. The interior of the case, E E is bored out for a short distance, and fitted with a lining of brass, turned out to receive the piston, NN, which plays freely along it. This piston forms the upper or receiving end of the converging pipe, C, called the combining tube which is connected at its smaller end with the diverging or discharging tube, D. This tube is cylindrical on its exterior, and plays freely in the brass bushing of M M, secured in the casting or outer shell, as shown in the cut.

Beyond this point again, a small stop-valve, P R, affords, when open, a lateral outlet to the tube, K; and beyond this again, a check-valve, is placed between the instrument and the boiler.

To put this apparatus in operation, the stop-valve, P R, is opened, and the steam plug, B, is closed; a little steam being let in, will escape through the small hole in the end of the steam plug, producing a vacuum, when the water is drawn up and forced through C and D into the pipe, K, from which it escapes by P. The plug, B, is then drawn back, so increasing the supply of steam, until the stop-valve, P, can be closed, without causing the injector to cease working. This ceasing to work will be indicated by an escape of steam from the water supply pipe. The action which is taking place in the apparatus, when thus in operation, may be briefly described as follows:

The steam passing into C is condensed by the water there combining with it from the water supply and the concentrated jet, is then driven through the delivery tube, D, into the pipe, K, from which, by raising the check-valve beyond, it passes into the boiler.

If, now, the water supply is, or becomes, too great; a portion of water escapes by the opening, O, in the portion connecting the combining and delivery tubes, and accumulating in the surrounding chamber, forces back the piston, NN, which, of course, carries with it the tube, C, &c., thus diminishing the annular space through which the water enters the combining tube, and so limiting its supply. If, on the other hand, the supply of water is not sufficient, the velocity of the steam jet will be increased and a partial vacuum will be produced in the chamber, and the piston, N N, will consequently be brought downward, thus opening the space for water supply, and correcting the defect.

We thus see that the instrument is self-regulating, and will adapt itself to changed conditions of pressure, so as always to develop a maximum result proportioned to the quantity of steam used.

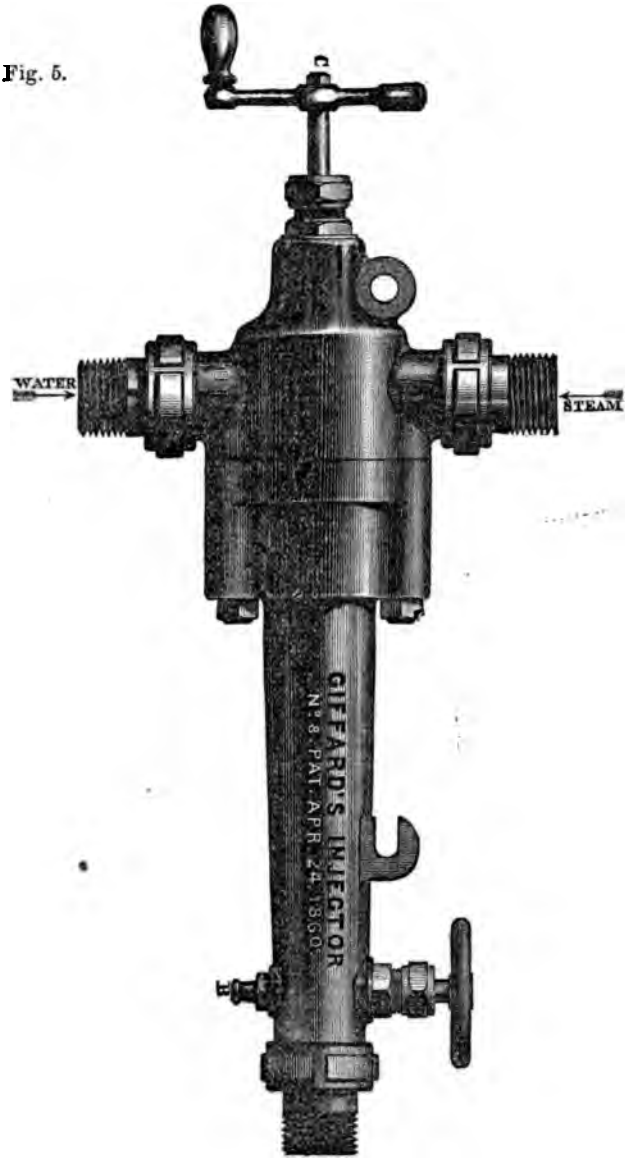
There are, besides this general principle and action, several other points claiming notice in this form of the instrument.

Thus it will be observed, that the conical plug, B, for regulating the steam supply, has a narrow passage bored along its axis, which communicates, by transverse openings, with the steam space around it.

By this means, when the plug, B, is forced all the way down, so as to close the outlet of A, a small jet of steam will pass by the opening in the plug, and will exert a much greater lifting force to raise

water from the supply into the combining tube, C, than will be produced by a jet of steam through the annular space between the plug, B, and nozzle, A.

Fig. 5.



The reason of this is, in part, as follows: To produce this lifting effect, which is quite dissimilar from that of the Injector in its ope-

ration connected with the introduction of water into the boiler, and is more nearly allied to the action of the exhaust in producing a draft in the smoke-stack of a locomotive; the effect depends chiefly on the free expansion and high velocity of the steam jet at the moment it escapes from the nozzle, A, (or the centre of plug, B,) and upon the existence of an outlet beyond, C, not only sufficient to allow this expanded sheaf-jet to pass freely, but also to give exit to the air carried with it by friction.

Now, in all these respects, the annular jet between the plug, B, and nozzle, A, is at great disadvantage, as compared with the orifice in the centre of plug, B.

Thus the friction is immensely greater in the annular jet, thereby reducing the velocity, especially if this jet is but slightly open; while on the other hand, if more space is given in the annular jet, the amount of steam discharged will be more than can pass freely by the nozzle, C, thus rather tending to produce a back pressure than a vacuum in C and the water supply pipe. In fact, it is found that where, with the old arrangement, an injector is able to raise its feed (water) from 2 to 6 feet, with this modification, it will lift its supply from 10 to 18 feet, depending upon the size of the instrument.

The exterior appearance of this instrument is shown in Fig. 5.

Having thus discussed, in a general way, the structure of the simple Injector itself, we will next pass to a consideration of those appliances which are as essential to its successful use and certainty of operation as similar appliances are to the efficient working of any of the old and familiar instruments, such as the ordinary pump.

This subject is of special importance, because it is so apt to be overlooked and neglected, for the reason that the novelty of the instrument here considered, makes it impossible that experience and tradition (as we may call it) should have thoroughly informed the mechanical public at large as to all the relations of this subject, as they have been informed with regard to apparatus longer in use, because of an earlier date.

(To be continued.)

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

BY PROF. HENRY MORTON, PH.D.

(Continued from page 64.)

HAVING discussed the characteristics of reflected light, we will now pass to the revelations which the light reflected by the moon makes as to the present state and past history of that satelite.

When the sun's rays fall vertically upon that portion of the moon which is exposed to our view, no shadows can be projected by the inequalities of surface, and all differences in appearance between various portions will depend upon specific differences in reflective power, and upon the angle at which the surfaces are presented to the incident rays.

This is the condition we find in the full moon. Thanks to the genius and also to the kindness of Mr. Lewis A. Rutherfurd, I am able to bring before you the very image of the moon, not only with the seeming brightness of nature, but with such enlargement of apparent size, that each one in the house will be able to perceive every detail as though looking through a telescope of great power. With reference to the production of these moon photographs, I shall have more to say presently, but first we will consider what they are and what they teach us. We will begin with the full moon, because that gives us a general view, and is most quickly disposed of, all detail being deficient from the absence of shadows, as explained above.

[A vast full moon, thirty-five feet in diameter, here seemed to glide in upon the stage, being projected upon the screen with such success, that notwithstanding its great size, it had a silvery or snowy brightness such as distinguishes the actual luminary. The glass picture employed was made by Mr. O. H. Willard, from one of Mr. Rutherfurd's negatives.]

The circumstance which I presume first of all strikes those unac-

customed to a telescopic study of the moon, is the entire *unlikeness* of this image, to the moon as seen with the naked eye. All resemblance to a human face has vanished, and in its stead we have a marked similarity to an orange, denuded of its rind.

This change of aspect is not peculiar to the photograph, but appears equally to the eye when its visual power is increased by the aid of the lenses in a telescope. In either case, the cause is the same, *i. e.*, marked details not before visible, attract the attention and obliterate the general impression which alone was realized before. Thus the strong luminous rays, which you perceive radiating from various points, are imperceptible to the unaided eye, while in the telescope they are the most characteristic features exhibited.

The cause of these luminous rays is by no means certainly determined otherwise, than that they result from a greater reflecting power in the lunar soil where they are traced; but how this more highly reflecting material came to be thus placed and distributed we can only conjecture. Certain significant facts may, however, well receive our notice.

All these rays or systems of luminous lines diverge from great volcanic centres. Thus the principal group has at its centre the volcano Tycho, whose interior basin or crater is fifty-four miles in diameter, with precipitous walls of 17,000 feet in height, and a central cone whose summit rises abruptly 4,000 feet above the interior plain.

The centres of the other marked systems are Copernicus, Kepler, Aristarchus, Anaxagoras, Petavius and Proclus.

In the next place, we find that one series of rays overruns and obliterates parts of another. Thus rays from Tycho obliterate those from Copernicus, never the reverse. Rays from Aristarchus obliterate those from Copernicus, while rays from Copernicus never obliterate those from Aristarchus.

Whatever, then, be the cause of their formation, they are at least intimately connected with these central mountains, and have been developed in such an order of sequence as the above statement indicates, Tycho being the last born of these volcanic giants.

Another and most perplexing feature of these luminous markings is, that they are neither ridges nor valleys, but coincide with the surrounding levels so as to produce no shadow at any time during the progress of the sunlight over the surface of the lunar globe.

Were the luminous bands hollow, we would say they were clefts produced by the volcanic action recorded so clearly at their respective centres, filled partly with white or polished lava. Were they ridges we would suppose them to be the result of cracks through which quantities of fluid rock had been forced up from below. But that the fresh material should have followed so closely the contour of the surrounding parts, requires other and more elaborate hypotheses to complete an explanation.

We may, however, well rest assured that these markings are the result of violent convulsions, having these various craters as their centres, by which the lunar crust was split open, and the interior, still fluid lava, extruded. Subsequent craters were formed in and encroached upon these markings, so giving them a broken and irregular appearance, but yet leaving their general shape and direction perfectly manifest.

It is only, however, at or near full moon that these markings show themselves in the power and distinctness of the picture which you now see upon the screen; at other times, only a few of them are strongly delineated, many are almost obliterated, and some quite disappear. The reason of this is obvious. These markings depend for visibility simply upon an unequal reflecting power on the surface. Now it is quite possible, from analogy with known substances within our reach, that this difference diminishes with an increase in the obliquity of the incident light. Thus with glass and black marble polished, the proportion of light reflected by the two substances at an angle of 30°, is 11 : 5, at 15° 30 : 15, and at 5° the proportion has reversed itself, being 54 : 60, that is, the marble here reflects most.* This example shows the possibility of what we suggest. Different bodies act in various and arbitrary ways in this respect, and as we do not know what is the nature of the lunar surface, we can only offer this as a conjecture. A more important cause of obliteration is however found in the strongly contrasted lights and shadows which cover the visible portion of the moon in her other phases, which would tend to mask and render imperceptible such slight differences of tint as these which we have been describing.†

* Daguin T. IV. p. 45.

† We have made no attempt to reproduce the photographic picture of the full moon, because, while such an engraving would be expensive and troublesome, it would be at best unsatisfactory and uninteresting, and if not executed with the greatest skill, a pictorial failure also, as is indeed the case with all the representa-

The phenomena of luminous streaks having been thus considered, we will call for another phase, which will serve us better in our continued investigation and study of other features.

[At a signal from the lecturer, the picture of a full moon was replaced by another, showing the appearance at a certain point of the third quarter. (See Plate II.) This was from a photograph made by Mr. Rutherfurd, on the 6th of March, 1865. The glass picture employed was prepared by Mr. O. G. Mason.]

In the first place, you will, no doubt, remark that this looks as little like the familiar moon, with its ugly human face, as did the orange-like full moon which it has replaced. We shall, however, be able to trace the most important features of our amiable satelite in this likeness with no more effort, perhaps, than is required for the recognition of a familiar face, in the first essay of many an amateur photographer.*

Thus we find the right eye of the moon's face in the partly shown circle of the Mare Imbrium, the left eye in Mare Serenitatis and Mare Tranquilitatis, the mouth in the southern portion of the

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tions which have been yet published, which look as little like the moon as an irregularly shaded circle well can.

We have therefore preferred to expend our time and the means at our disposal upon reproductions of the other phases, which offer a better opportunity to the artist, and are moreover of infinitely greater use to the student, because showing those details of structure and topography which are wanting in the full phase.

Plate II. which accompanies this number of our *Journal*, is a carefully reduced copy of the photographic print made by O. G. Mason, of New York, from a negative taken by Rutherfurd, on the 6th of March, 1865.

Some of the details at a distance from the terminator (dividing edge of illumination and shadow), are more fully defined than they could be in the phase here shown, by reference to another print of an earlier phase, prepared also by Mr. Mason, from a negative bearing date March 4th, 1865, and like the former and others to be described in future, kindly presented to us by Mr. Rutherfurd.

In the accompanying plate II., will be seen some few of these luminous rays, the most marked proceeding from Tycho near the South Pole, another set from Petavius (60) near the south-west border, and another from Proclus (near 78), on the eastern border of the Mare Crisium. As we have already stated, these markings would be vastly more numerous and distinct in a view of the full moon, but this will serve to indicate their character.

* In comparing what immediately follows with the plate, it must be remembered that for convenience of reference, this is lettered in the position in which it is seen in the telescope (*i. e.*) inverted from its natural attitude. To compare this plate, therefore, with the moon, as seen by the naked eye, we must turn the plate so that the lettering will be upside down.

Mare Nubeum, the very irregular profile of the nose in the plains which stretch north and south along the terminator, and the marked dimple in the chin appears as no less than that grand volcanic centre, Tycho.

Having then assured ourselves of the truthfulness of the picture, let us next consider those details which have nothing to do with this likeness to the familiar moon, since they are only visible in the telescope or the photograph.

These darker regions of a circular form are still called and were once believed to be seas, but we now know them to be simply arid wastes, owing their deeper tint to a darker color, or the less reflective character of their soil. Their universally circular form leads us to believe that they are only enormous craters of ancient volcanoes, on the wall and over the area of which, lesser and subsequent eruptions have formed smaller cones and rings.

Such a condition of things we find, in fact, repeated in most of the smaller volcanoes, whose ramparts and plateaus are dotted with smaller cones. [It is impossible, however, to represent these correctly on so small a scale as in Plate II. The names of these various so-called oceans, and the ranges which border them, will be found on the plate, and also on the page facing it, as also the names corresponding to the numbers by which the individual peaks and smaller objects are indicated.]

This circular form of all mountain ranges, is one of the many characteristics by which the lunar topography departs from all terrestrial analogies. The characteristic of our mountain ranges is their general rectilinear direction and frequent parallel arrangement; but in the moon no instance of such a formation is to be found.

Another point which impresses itself strongly, is the absolute blackness of all shadows. We do not here refer to *shades*, such as are due to differences of surface and are found with every variety of gradation, but to the veritable shadows cast by ranges, rings and cones, and which are absolutely black and without detail.

The origin of this is to be found in two conditions, the absence of an atmosphere, by reason of which there is no diffused light reflected from the sky, by which, in our own case, terrestrial shadows are illuminated; and the vast distances of objects from one another, by reason of which the light which one reflects is scattered and lost before it can reach the other.

(To be continued.)

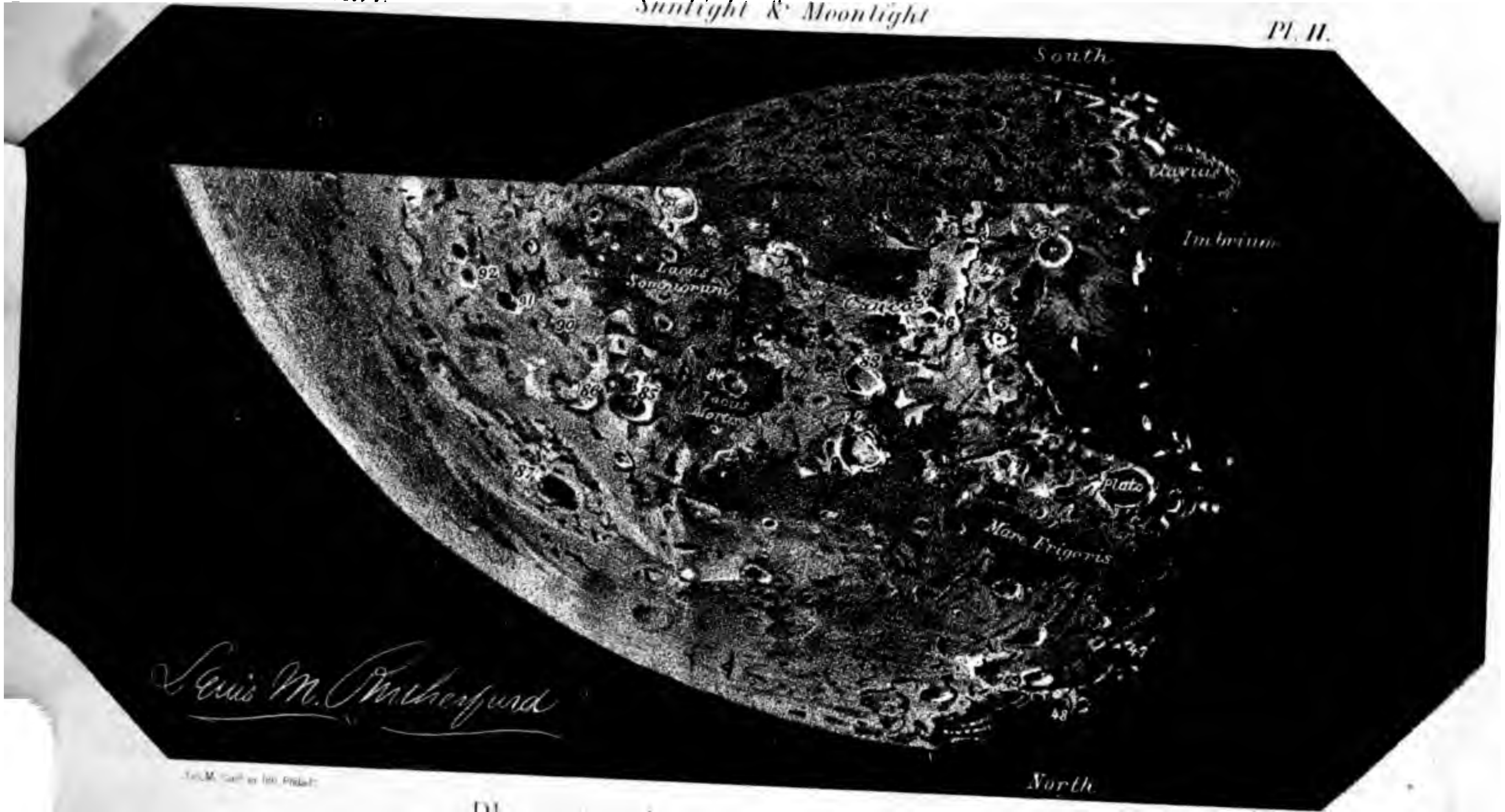
KEY TO PHOTOGRAPHIC LUNAR MAP.

The accompanying plate is at once a photographic view and map of the moon. It is, in the first place, a copy made with the greatest care from one of Mr. L. M. Rutherfurd's moon photographs, 20 inches in diameter, and upon this the names and numbers of reference have been inserted by reference to the unequaled moon map of Beer and Maedler. The position given to the plate is that of the moon as seen in the telescope, as it is then only that the details shown are visible. For comparison with the moon, as seen by the unaided eye, the plate should be simply inverted, so that the lettering is upside down. The numbers begin at the South pole, and, after going over that region, continue in progression by an irregular path, near the edge of the luminous portion, to the number 49, after which they go back to the southern part for 50, and then again descend to the northern region.

We give a list of the names engraved on the plate, to assist reference. Beginning with the region about the South pole, and go end downward and from left to right, we have:—

Clavius, Tycho, Pyranœi Montes, Mare Nectaris, Altai Montes, Mare Nubium, Mare Fœcunditatis, Mare Tranquilitatis, Mare Vaporum, Copernicus, Mare Crisium, Taurus Montes, Mare Serenitatis, Hœmus Montes, Apenninus Montes, Mare Inbrium, Lacus Somniorum, Locus Nortus, Caucasus Montes, Alpes Montes, Plato Mare Frigoris.

1. Maretus.
2. Zach.
3. Lilius.
4. Maginus.
5. Longomontanus.
6. Wilhelm I.
7. Saussure.
8. Nasireddin.
9. Stofler.
10. Cuvier.
11. Clauraut.
12. Baco.
13. Pitiscus.
14. Vlacu.
15. Maurolycus.
16. Lexel.
17. Walter.
18. Aliacensis.
19. Werner.
20. Gauricus.
21. Hell.
22. Pitatus.
23. Purbach.
24. Thebit.
25. Arzachel.
26. Alpetragius.
27. Davy.
28. Guerike.
29. Parry.
30. Alphons.
31. Ptolemaus.
32. Herschel.
33. Lalande.
34. Mosting.
35. Pallas.
36. Bode.
37. Stadius.
38. Eratosthenes.
39. M. Wolf.
40. Timocharis.
41. Archimedes.
42. Autolycus.
43. Aristillus.
44. Theœtetus.
45. Cassini.
46. Calippus.
47. Epigenes.
48. Anaxagoras.
49. Barrow.
50. Albategnius.
51. Abulfeda.
52. Almanon.
53. Geber.
54. Azophi.
55. Abenezra.
56. Playfair.
57. Apianus.
58. Picolomine.
59. Furnerius.
60. Petavius.
61. Fracastor.
62. Sanbeth.
63. Vendelinus.
64. Langranns.
65. Cook.
66. Gœlenius.
67. Guttemberg.
68. Theophilus.
69. Kant.
70. Affraganus.
71. Taylor.
72. Sabine.
73. Arago.
74. Agrippa.
75. Triesnecker.
76. Ross.
77. Vitruvius.
78. Palus somnii.
79. Macrobius.
80. Rômer.
81. Posidonius.
82. Bessel.
83. Linné.
84. Burg.
85. Hercules.
86. Atlas.
87. Endymion.
88. Eudoxus.
89. Aristoteles.
90. Copheus.
91. Franklin.
92. Berzelius.



Photographic Map of the M

LECTURES ON VENTILATION.

BY LEWIS W. LEEDS.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

LECTURE I.

PERHAPS no subject relating to the health of the human system ever gained favor more rapidly, (without advertising,) than has the subject of ventilation within the last year or two, and I think we may refer to the report of the Board of Health, for the year 1867, as a substantial and most gratifying proof of this assertion.

In the year 1865, there were 17,169 deaths in this city; in 1866, there were 16,803, and in the year 1867, there were only 13,903, or a saving of 2,870 lives in the last year, and 3,237 in the two years, and this, too, notwithstanding an increase of population probably equal to 20,000 per annum.

The saving to the citizens of Philadelphia by the diminished mortality, and the sickness represented thereby, could be scarcely less than three-quarters of a million a year; or sufficient to pay the entire expense of our excellent system of public schools.

Could this decrease in the rate of mortality be continued we would soon be a very healthy people; perhaps this is almost too much to hope for.

I do believe, however, that this rate of decrease in the mortality may be continued through the year 1868, and with a cash outlay, if judiciously expended, no greater than will be returned to us penny for penny and dollar for dollar within twelve months thereafter.

No healthy condition of the human frame can be maintained without we breathe pure air, and although there has been a wonderful improvement in this respect within the last few years, yet we still do not breathe pure air one-half our time.

Our arrangements for the artificial ventilation of our houses in winter and at night, are still exceedingly imperfect.

The great majority of our citizens scarcely realize the true value of pure air, or hardly know how to obtain it economically at all times. We need more public education on this subject.

There has long dwelt in the minds of many persons a kind of

vague idea that ventilation was a good thing in its way; but with nine-tenths of the whole people, the chief concern has been to *obstruct* all circulation of air, to stop all draughts, and thus practically to prevent any *ventilation*, especially in winter.

In the good old days of open wood fires, when, as in our childhood, the real chimney-corner was the family sitting-room, so to speak, or at least, for the children, then, with all the listing of doors, caulking of windows, and filling up of key-holes, there was certain to be still an abundance of fresh air, that would force its way into the room in spite of all efforts to keep it out. But with the introduction of anthracite coal and air-tight stoves, and still worse, steam-pipes, placed in the room for heating by direct radiation, the stopping of all draughts that were before so annoying, became a matter of easy accomplishment.

The results thereof have been perfectly frightful, persons have thus unconsciously been smothered to death by the thousands and tens of thousands.

It seemed almost impossible to arouse the public from the quiet, satisfied stupor that followed their great victory over their old enemy—the whistling winter wind.

Those that have not gone to their long homes during this dark winter-night of stupor and ignorance, may well rub their eyes in astonishment, as they awake to a consciousness of the dangers they have so marvelously escaped.

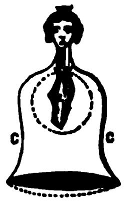
The poor man, too, as well as the rich, should feel that he has no truer or more valuable friend on earth than fresh air. His food, though coarse and simple, will digest more fully and quickly with an abundance of pure air. His head is clearer, his chest expands and his muscles grow stronger, as his heart grows lighter, and he goes cheerily on day after day with his laborious toil, returning at night to his home and fireside, surrounded by his wife and little ones, a happy man, made so by the consciousness of having been able to do and having done a good day's work. He enjoys a night of sound sleep, when sleeping with open windows, and wakes refreshed in the morning, ready again to commence the toils of another day.

The Doctor's explanation of the physiological effect of breathing air, whether pure or impure, is very interesting.

We cannot, of course, expect to go into a regular medical or physiological lecture at this time, but we must just examine some of the main points so as to get a general idea of the effect produced by air

of different qualities, and if possible, to form some conception of the manner of its action. I have here a little arrangement by which I wish to represent the action of the lungs.* It is simply a glass bell jar with a piece of rubber stretched over the bottom, which is intended to represent the human diaphragm. From the mouth of the figure-head there is a small tube extending downwards, and this represents the wind-pipe, at the end of this is another piece of rubber, which we will suppose to represent the lungs. Now, as I draw down the diaphragm, the space in the jar is enlarged, and a partial vacuum is created, and the air rushes down the wind-pipe to fill the space.

Fig. 1.



It is prevented, however, from getting directly into the body by the lungs, which being elastic, or rather all folded up in innumerable little folds, expands and contracts with great ease. The power, therefore, does not lie in the lungs so much as in the diaphragm and ribs, the air is forced out and in the lungs, similar to the manner in which it is forced out and in a pair of bellows.

The lungs are composed of an immense number of air-passages, with innumerable branches, we might say, perhaps, like the branches of an apple tree, and at the extreme ends of these branches are air-cells instead of apples, the number of these little cells is estimated by some to amount to six hundred millions.

The aggregate surface of all these air cells is variously stated by different physiologists from 600 to 1500 square feet. So, if this room was 30 $\times$ 40 feet, the surface of the lungs of a single person would, if spread out, be sufficient to carpet the whole room.

These air-cells are perfectly surrounded by a complete net work of minute blood vessels, through which flows the dark, impure blood that has just returned from the most extreme points of the body, bringing with it, dead, diseased, old, worn out particles of the body, and the carbonic acid, or what we might call the ashes resulting from the combustion of the oxygen, which is constantly required to keep up the heat of the body.

Now, it is when this impure blood on one side meets the pure air on the other, that the most wonderful change takes place.

This membrane of these air-cells of the lungs is so exceedingly delicate, that there is a chemical transformation or exchange takes place at once.

The carbonic acid, and other impurities from the blood, pass

* Griscom's "use and abuse of air."

through this fine membrane of the lungs, and are absorbed by the air, while the oxygen of the newly breathed air passes through the lungs into the blood, which is thus changed from a dark color to a bright, light colored red, and oxygen is thus carried to the hundreds of little capillaries in the most remote parts of the body to the skin, and to the bones, to the brain and to the stomach, and there burned to keep up the heat of the system, and to cook the food we have eaten, (if the Doctors will allow me to express in that homely manner, the beautiful and very elaborate process in which the fresh air we breathe acts in digesting and utilizing our food.)

But suppose, instead of the air thus introduced into the lungs being pure, it is impure, or already loaded or charged with carbonic acid by previous breathing, then it cannot take up the impurities of the blood, and instead of its being changed by the absorption of oxygen to a beautiful bright red, it remains of a dark, dull color, consequently these impurities have to be carried back to all parts of the system, instead of the much needed oxygen; disarrangement of the whole system soon follows to a greater or less extent, according to the proportion of the impurities in that air.

The little air-cells of the lungs also become choked up with this refuse material, which causes what is familiarly called consumption. You all know if you allow the ashes to accumulate so as to fill the entire space underneath the grate, that the grate will soon be burned out. In a manner very similar to this will that exquisitely thin, delicate membrane of your lungs be destroyed, if you neglect to breathe sufficient pure air to carry away all the ashes from the immense number of fires constantly burning in your body.

The frequency of these interchanges between the air and the blood, the very large aggregate amount of each that daily passes through the lungs, ought to impress us with the great importance of a careful attention to maintaining the best conditions for perfect health.

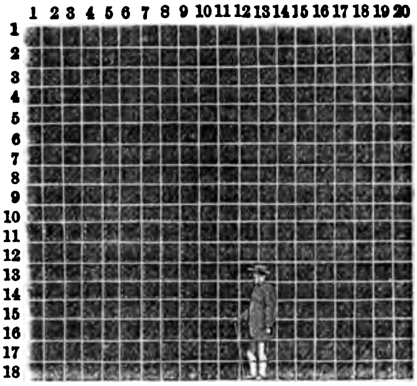
But, in too many cases, our estimate of the value of things is based upon the dollars and cents it costs us, and as no patented monopoly has ever been able to control the supply of pure air, so as to dole it out to us by the dollar and cent's worth, but it is kept constantly poured around and over our houses in the most lavish profusion, yet we have in many cases treated this wonderful bounty of the Creator with shameful neglect.

I have prepared a diagram by which I hope to impress upon your minds the amount of air breathed by each individual in twenty-four hours. It is 18 × 20 feet, and intended to represent one foot thick;

this gives 360 cubic feet of air, or 125 times the whole bulk of a man.

This, of course, is given merely as an average. The amount breathed varies very greatly from many causes,—some per. sons may breathe at times nearly double this amount, and at others not half so much. The average number of respirations are estimated at about 20 per minute, and the amount inhaled at each respiration is about 10 cubic inches.

Fig. 2.



We do not completely fill and empty the lungs at each breath, on the contrary, the lungs contain 150 to 200 cubic inches of air, so that about one-eighth only of the contents of the lungs is changed at each breath. I believe Physicians have scarcely determined positively how this air remaining in the lungs is quickly and constantly purified.

The diffusion of gases, which I hope to explain in our next lecture, has much influence, no doubt, in removing the excess of carbonic acid from the remaining air, and saturating the freshly entering air before it is inhaled.

Some physiologists explain, that the carbonic acid, and other impurities, are expelled from the minute cells by the muscular contraction of the circular organic fibres, and are thus delivered into the larger branches in which diffusion at once takes place with the air just introduced.

I wish to show you here what proportion of the air breathed daily is oxygen, as that is the very important element in the air. It occupies in bulk about twenty-one parts in the hundred, or a little more than one-fifth of the whole. The other four-fifths being mostly nitrogen. The use of this latter gas, the nitrogen, has scarcely been determined, it is thought by many to be merely a dilutent of the oxygen to keep it under control, so that it shall not take fire spontaneously, and burn everything up.

So much for the air we breathe; the blood, of course, continues the connection from the lungs to all parts of the body; and let us examine that for a few moments.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, June 17th, 1868.

THE meeting was called to order with the President, Mr. J. V. Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, June, 10th inst., donations to the library were received from the Royal Astronomical Society, the Royal Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; la Société Industrielle, Mulhouse, France; the Canadian Institute, Toronto, and Major L. A. Huguet Latour, Montreal, Canada; his Excellency, Rawson W. Rawson, Governor of the Bahamas, through John H. Redfield, Esq., Philadelphia; Frederick Emmerick, Esq., Washington, D. C., and Hon. Wm. J. McAlpine, Stockbridge, Mass.

The various standing committees reported their minutes.

The report of the Resident Secretary on Novelties in Science and the Mechanic Arts was read, in the course of which a description was given of a new form of safety hoisting apparatus, invented by Messrs. Merrick Bros. A description and drawing of this will be found in our editorial department.

Mr. William Sellers, Chairman of the Committee appointed to report on the expediency of an Exhibition of National Industry by the Franklin Institute, stated, that in answer to an inquiry addressed to the Board of Managers by members of the Institute as to the reasons for deferring such an exhibition until after the fall of 1868, he had been authorized to explain, that the reason of this postponement was the conviction that the serious financial outlay which must be made by the Institute, in erecting a suitable building for the purpose of an exhibition (no existing edifice in the city being fit for the purpose), was not likely to be reimbursed by the receipts of an exhibition amid the excitements of the coming Presidential election.

The meeting was then, on motion, adjourned until the third Wednesday in September.

Bibliographical Notices.

The Lathe and its uses; or instruction in the art of turning wood and metal; including a description of the most modern appliances for the ornamentation of plane and curved surfaces; with an appendix, in which is described an entirely novel form of lathe for eccentric and rose engine turning; a lathe and planing machine combined; and other valuable matters relating to the art. Copiously illustrated. Published by John Wiley & Son: New York. For sale by J. B. Lippincott, Philadelphia.

A useful book, full of valuable information, very clearly expressed. We have examined it with care, and heartily recommend it to the professional mechanic as well as to the amateur. To the latter it is invaluable, but we are sorry to say, it has two grave faults. In the first place, while many of the wood cuts (of which there are about 500), are excellent, some are so poorly executed as to be but mere sketches of the devices described.

Then there is no index, in other words, what is pre-eminently fitted to be a work of reference, fails entirely to fulfil its proper mission, for lack of this simple but essential ingredient.

On one page, in reading the volume, we found the description of a method for soldering work to a face plate or chuck, by using sal ammoniac in solution, and tin foil, as the flux and solder. This is described as a useful "dodge." We naturally wondered if the writer was familiar with the much more efficacious soldering liquid chloride of zinc, and if he described how to prepare and use it. This led us to look for an index, but none was to be found, and then, loosing the page upon which the original useful dodge was given, we can only hope to find it again by a careful re-perusal of the book. We cannot too severely censure this carelessness, in issuing a good book (which is essentially a book of reference,) without a key to its contents. It is an imposition upon the public, and a serious injury to the actual value of the work.

We have ready, notices of the following new publications, which have been crowded out of this number:

Metallurgy of Iron. By Bauerman. *Gas Works of London.* By Colburn. *Lessons in Elementary Chemistry.* By Roscoe. *The Institutes of Medicine.* By Paine. *Instruction in the Practical Use of the Blowpipe.* By Plympton. *Mechanic's Tool Book.* By Harrison.

A COMPARISON *of some of the Meteorological Phenomena of* JUNE, 1868, *with those of* JUNE, 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 11¼' W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	June, 1868.	June, 1867.	June, for 17 years.
Thermometer—Highest—degree	90·00°	88·00°	98·00°
" date	20th.	15th & 16th.	29th, '56.
Warmest day—mean	83·83	80·33	90·50
" " date	20th.	30th.	30th, '56.
Lowest—degree	51·00	48·00	42·00
" date	3d.	9th & 11th.	5th, '59.
Coldest day—mean	56.50	53·50	53·50
" " date	11th.	9th.	9th, '67.
Mean daily oscillation	15·97	17·07	16·13
" " range	4·10	4·39	4·76
Means at 7 A. M.	67·12	67·60	68·71
" 2 P. M.	77·85	77·17	78·73
" 9 P. M.	70·85	69·67	71·27
" for the month	71·94	71·48	72·90
Barometer—Highest—inches	30·292	30·309	30·309
" date	4th.	11th.	11th, '67.
Greatest mean daily pressure	30·274	30·270	30.274
" " " date	4th.	11th.	4th, '68.
Lowest—inches	29·629	29·474	29·182
" date	20th.	3d.	11th, '57.
Least mean daily pressure	29·643	29·586	29·262
" " " date	20th.	3d.	11th, '57.
Mean daily range	0·119	0·105	0·101
Means at 7 A. M	30·000	30·006	29·830
" 2 P. M	29·970	29·986	29·797
" 9 P. M	29·978	29·994	29·812
" for the month	29·983	29·995	29·818
Force of Vapor—Greatest—inches	0·815	0·798	1·059
" date	20th.	17th.	30th, '55.
Least—inches	·255	·183	0·162
" date	4th.	10th.	5th, '59
Means at 7 A. M	·501	·524	·515
" 2 P. M	·540	·521	·537
" 9 P. M	·551	·540	·551
" for the month	·531	·528	·534
Relative Humidity—Greatest—per cent	94·0	95·0	100·0
" date	12th.	25th.	6th, '56.
Least—per cent	35·0	28·0	22·0
" date	30th.	10th.	16th, '68.
Means at 7 A. M.	74·3	75·8	72·5
" 2 P. M.	56·7	56·3	54·3
" 9 P. M.	72·2	72·7	70·7
" for the month	67·7	68·3	65·8
Clouds—Number of clear days*	7·	8·	8·2
" cloudy days	23·	22·	21·8
Means of sky covered at 7 A. M	62·0 per ct	66·3 per ct	59·8per ct
" " " 2 P. M	66·0	61·7	61·2
" " " 9 P. M	51·3	52·7	45·5
" " for the month	59·8	60·2	55·5
Rain—Amount—inches	3·69	10·950	4·674
No. of days on which rain fell	11.	11·	11·6
Prevailing Winds—Times in 1000	N12°32'W.058	S 86°52'W.059	S78°57'W. 204

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] SEPTEMBER, 1868. [No. 3

EDITORIAL.

ITEMS AND NOVELTIES.

An Immense Machine Tool.—In our last number we alluded to a Vertical Boring and Turning Machine of unusual dimensions, which we had seen just completed at the establishment of Messrs. Bement & Dougherty.

Want of space then prevented us from inserting a description of this remarkable piece of machinery, which we will now give with the accompanying plate, which will assist in making our description clear.* The uprights being movable, will allow an object of 23½ feet in diameter to be turned, while the greatest diameter for boring with the uprights in position is 12 feet, a height of 9 feet being also admissible.

The centre piece, or bed, weighing 26,000 pounds, is 10 feet 4

* It should, however, be remarked that this figure represents a machine to cut and bore but 12 feet; in the larger apparatus the dividing works are carried out 6 feet.

inches square, and supports the table by two bearings, formed by the anti-friction curve or curve of equal tangents. The lower bearing is in reality a continuation of the upper one; a portion of the curve being omitted on account of its great length, and the lower part of the curve is moved up so as to get the advantage of the two extremes of the curve with less depth of bearing. The largest diameter of the upper bearing is 6 feet 5 inches, and has 9½ in vertical height; the smallest diameter of the lower bearing is 10½ inches, and has 24 inches vertical height. These bearings are lined with first-class Babbit metal (made at the works) after the bearings of the table are polished and set in the proper place on the bed, thus obviating the turning of the bearings in the bed.

The table is 8 feet diameter, weighing 14,000 pounds, on which is fitted a loose face-plate ring, 12 feet diameter, weighing 7,000 pounds. The table is driven by two sets of gearings. For fast motion, the table is driven from below by a pair of mitre-gears 34 inches diameter, 7 inches face. For slow motion a bevel-gear is cast under the table 94½ inches diameter, 7½ inches face, into which gears a pinion, 11½ inches diameter. The hub of this pinion is a little larger than the outside diameter of the teeth, and runs in a bearing close up to the table, thus allowing the pinion to be drawn out of gear through the bearing, which is done by means of a nut connected with the pinion, and a thread cut on the driving shaft, when the table is to be driven from below.

The driving cone is 6 inches face, and has 5 changes from 17 to 34 inches diameter; the machine is back-geared; on the cone-shaft are two pinions which are brought into gear to drive the table either from above or below.

There are two cheeks, bolted on opposite sides of the centre-piece, to receive the uprights. They are 24 inches wide, 30 inches high, and 21 feet long, weighing 14,000 pounds each. They have planed grooves, into which fit corresponding projections under the uprights. The tail ends of the cheeks are tied together by a brace bolted between them.

The uprights are 13 feet 3 inches high, have a base of 8½ feet in length, and 30 inches in width, each weighing 11,000 pounds. The upper parts of the uprights are connected by a brace 3 feet deep, weighing 3,000 pounds. The uprights are moved together by screws driven by power.

The cross-slide is 33 inches high, 22 inches deep, with hollow curved back, and 15 feet long, weighing 11,000 pounds, and is

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raised and lowered by screws driven by power through two tangent-wheels. There are two heads on the cross-slide, one for turning, facing and boring, with self-feed at all angles, and the other for drilling. The stand carrying the driving cone and back-gear for the drilling head is bolted on top of the brace connecting the uprights. The drill-spindle is steel, 4½ inches diameter, and has 18 inches travel, with self and hand feed.

The Dead-Stroke Hammer in England.—At the meeting of the Manchester Institute of Engineers, notice was taken of the Dead-Stroke Power Hammer of Messrs. Shaw & Justice, of this city. This hammer being a Philadelphia invention, we feel a natural interest in its reception abroad, and are glad to record the good opinions it receives. Mr. James Fletcher, of Manchester, who introduced the subject to the above meeting of engineers, in the course of his remarks, alluded to the many varied attempts which had been made to produce a power hammer that could be driven by a strap from a line shaft, and still possess all the essential qualities of a steam hammer, viz: to strike light or heavy blows, to run quick or slow, to be perfectly under control, and capable of being stopped instantaneously.

Mr. Fletcher stated that the Shaw & Justice hammer was one of those peculiar and simple inventions, so many of which have emanated from our cousins across the Atlantic; and that it possesses a great many advantages over all others; such as taking less power to drive it, so that he had no doubt that the same amount of steam which it takes to work a steam hammer, would drive by means of an engine, at least three of these hammers, each doing the same amount of work, for the reason that in the steam hammer, the entire cylinder must be filled with steam, even when a short stroke is made, thus causing a waste of power, which clearly does not occur in the other apparatus. Another merit mentioned was its simplicity in working, so that no instructions are necessary, but that any boy in a smithy can manage it.

The Illinois and St. Louis Bridge.—Report of the Engineer-in-Chief, James B. Eads, C. E.—We have read, with great interest, this pamphlet of portly dimensions, and shall, in a subsequent number, give some extracts from its most interesting portions, which want of space alone prevents us from introducing at the present time. In the meantime, however, we will make a general review of the work, and express freely our opinion both of agreement and dissent.

The entire report may be well considered in its two divisions of main Report and Appendix, the first being a general treatment of the subject, in a popular manner, for the benefit and instruction of stockholders and the non-professional public at large, and the last comprising a thorough analytical investigation of the whole problem. This latter portion, which is of the greatest interest to all professional engineers, Capt. Eads informs us, has been prepared by Messrs. Fladd and Pheiffer, of his staff, and to these gentlemen great credit is due for the masterly character of their work, displaying as it does a familiarity with the practical application of the higher analysis not often to be met with even among engineers, and without which no work like the St. Louis bridge could be intelligently designed.

Prof. Chauvenet bears his testimony to the accuracy of the calculations, and thus gives them the highest possible endorsement.

The problem involved in the consideration of an arched rib, is one of peculiar difficulty, especially when the rib is neither hinged at the crown or abutments. The method adopted is the one employed by Sternberg for the great ribbed arch over the Rhine, at Coblentz, the drawings for which appeared in our valued cotemporary, *Engineering*, some time since. Some modifications were necessary in the method of Sternberg, who treated the centre line of the arch as a parabola, and also considered the arch as *hinged* at the skewbacks. In the bridge before us, the ends were considered *fixed* at the piers, which reduced the computed deflections caused by the load under the hinged condition, allowing of a reduction of the weight of the material, provided a short distance from each end was strengthened. This last provision was required from the fact, that with fixed ends, the deflections were greater near the abutments than when the ends were hinged, and also because the effects from change of temperature were increased.

The ribs are formed from two circular flanges, separated about nine feet from each other by a system of triangular bracing. In this not only lies the carrying system, but it also contains the provision for counter-bracing, the spandril filling merely serving to support the roadway. The arch, therefore, acts in the double capacity of a rib under direct compression, and a beam under a transverse load, and the strains at each point are the resultants of the strains arising from the direct compressive action of the load, and from its bending action. Messrs. Fladd and Pheiffer have treated this question in a most thorough manner. The appendix is made complete

by lithographed sheets showing curves of strain under various conditions of the load, the whole forming one of the most admirable investigations of the kind that we have ever seen. We should mention that the full analytical considerations of the masonry are given, as also effects of wind upon the superstructure, and the gorging of ice against the piers.

The portion of the report written by Capt. Eads, is entirely descriptive, principally in defence of the plan determined upon, viz: three cast steel arches, of 500 feet span, in preference to any other, on the score of economy. His points are ingeniously and ably taken, but we do not think that the conclusions are always sound and reliable. We cannot speak too highly of the clearness and perspicuity of style in which the various subjects are discussed, and entirely agree with the reasoning adopted as to the relative economy of the arch and truss girder for long spans.

It will be remembered that, during the summer of 1867, Mr. Boomer called a convention of engineers, at Chicago, to consider the best plan of uniting the Missouri and Illinois shores by a bridge. He controlled a charter for the purpose, and was opposing Captain Eads, who also controlled a charter. This convention of Mr. Boomer's, after several days' deliberation, made a report upon questions involved in such a bridge, which was afterwards printed in pamphlet form, for distribution among those interested. The only style of bridge recommended, or even considered, was a truss, the maximum spans of which, it was agreed, should not exceed 368 feet. Commenting upon long spans, the convention declared, in their report, that there was no engineering precedent for spans of 500 feet, which would furnish them with any reliable data on the questions of material and workmanship in spans of such great length.

This was a direct and, as it appears, very inconsiderate stroke at the "Eads Bridge," and, in his report, Capt. Eads retorts by a description and drawing of the Kailinburg bridge, a truss bridge with a curved top chord, of the enormous span of 515 feet, precisely the span of the centre arch of the St. Louis bridge. The convention at Chicago avoided the consideration of the arch bridge; but Captain Eads does that work for them in his pamphlet, and handles the *ex parte* character of the convention very sharply.

The fact is, the convention only examined Mr. Post's style of truss bridge, and reported on that exclusively, as that was the de-

sign Mr. Boomer had decided to build upon before he called his convention together to take into consideration the best method of crossing. As they had, therefore, but one plan to consider, they reported rightly upon it, although it must be confessed that it was injudicious so to word their report that this limit of its bearing was not more apparent; if they had been permitted to discuss the subject of long-span bridges generally, without being confined to one principle of trussing, the result would have been of far greater value to the profession at large.

Captain Eads' case, we think, is not so strong, when he considers the question of the relative economy of suspension and upright arches. He claims that cast steel can be worked up to its *full* elastic limit when under compression, though only up to one-half its limit under tension. "If steel were but one-half stronger in compression than in tension, then two-thirds of the material only would be required to give the same strength in the upright arch that would be required for the suspended one. In that case, an upright arch having 1,000 tons of cast steel properly disposed throughout its length, would sustain as great a load as 1,500 tons in the suspended form." The reason assigned for this difference is, that a yielding, in the case of tension, means an utter downfall and destruction of the work, while in the case of compression, it implies only a mashing out of parts, and, therefore, an increase in section and resistance. This assumes, as it appears to us, that the mashing out has no injurious effect upon the structure of the material, an assumption which requires experimental proof. The number of experiments on the compressive resistance of steel are very meagre, although those in the tensional resistance are numerous. According to all existing authorities, *no* material should be worked up to its full elastic limit; and we cannot, without further demonstration, agree with Captain Eads in thinking it safe so to do. Engineers endeavor to keep far within this limit of elasticity, with good reason, we think, as Mr. Fairbairn's experiments on the impact of girders satisfactorily show.

We very much doubt if cast steel can be worked compressively to a better economical advantage than properly manufactured *steel wire*, although we admit that it has a manifest advantage over steel in the form of links, although not nearly so great as in Capt. Eads' estimates. A chain can be proportioned to the exact section theoretically required, while under compression suitable bracing, vertically and horizontally, must be introduced to prevent flexure,

beside the mechanical requirements necessitating an excess of metal for making proper connections of the several parts. It is one thing to compute the metal required in a structure from a simple diagram of strains, and another to arrange these parts to perform their duty, in combination with the practical requirements of actual construction. Parts in tension can almost always be worked up nearer to theoretical requirements than parts in compression. The extension of the cables to their anchorage forming the approaches, Captain Eads dismisses by the single remark, that a "less expensive method is *most* always practicable;" but he does not say that it is so in this case. As to the towers, he does not put them under the most favorable consideration, as he assumes the massive masonry required for an arch is carried up to form the towers, while it would be manifestly more economical to sink pneumatic piles, and have braced wrought iron towers upon them. As to the anchorage masonry, as compared to that required to receive the tremendous thrust of the land arches, we think there would be very little difference, especially if the masonry for the arches is founded in water, which would not be the case for the anchorage of the suspension bridge.

Calling the traveling platform the same in both, the suspension bridge requires a truss to enable it to conform to the conditions of equilibrium under a variable load. This truss would be a light one, and, perhaps, would not require any more material than the braced standards supporting the platform of the arched system, which are some fifty feet high near the abutments. The comparative cost of erection is largely in favor of the suspension is admitted without argument, it being just as well not to say too much about the difficulties involved in the erection of an arch of 500 feet span without false works, which Captain Eads must admit has no "engineering precedent," except in Telford's brain, and which he had no opportunity to carry out. We do not want to be understood as descrying the St. Louis bridge; we want to see it built, and we believe it can be. Further, we believe the spans proposed are within the powers of steel construction; but a comparison should be fair, and this we do not think has been quite the case in that made with the suspension principle. This, however, is quite natural, in view of Captain Eads' great difficulties in forwarding his scheme financially, and in view of a laudable ambition to build a steel arch-bridge of the greatest span hitherto attempted. We wish him all success, and hope that he will favor us and benefit the pro-

fession with a full account of his experiments upon steel, a machine for which, he informs us, he is having built.

The Southport Pier.—New method of sinking iron piles in sand. At the last meeting of the Franklin Institute, there was exhibited by means of a photograph projected on the screen, the structure of the Southport Pier, and the means used for sinking the piles on which it is supported. Both the structure and the process employed in its erection are remarkable for simplicity, economy and adaptation to the existing conditions.

This pier, capable of resisting severe strains from wind and water, as experience has proved, capable of sustaining a load of thirty-five tons for each bay, 3,600 feet long, and fifteen feet wide, with approaches, tool house, &c., was constructed for $46,595. The entire number of piles (237), were sunk in the space of six weeks in a location where work could be prosecuted only at low tide.

The methods employed for sinking were as follows: The lower ends of the piles were provided with circular disks one foot six inches in diameter, on which projections or cutters were cast, and through which, at the centre, passed a pipe delivering water from the regular mains under a pressure of fifty pounds to the square inch.

The pile was supported and lowered, as necessary, by a small piling machine, and a rotary reciprocating motion being given, the sand, &c. was loosened from beneath and carried away by the stream of water. The water being stopped, the pile settled, so as to sustain twelve tons without moving, in five minutes.

The Zentmayer Lens.—At a late meeting of the Franklin Institute, were exhibited a series of glass positives, made by Mr. E. Borda, from negatives which he had taken during the past season, with one of Mr. Zentmayer's lenses of 3½ inches focus, such as are supplied for stereoscopic work.

The subjects of these views were, as a rule, waterfalls and sheets of water found in the picturesque region of Pike Co., Penn'a.

The pictures projected on the screen, as usual, were of a most beautiful character, and elicited warm commendation from all present, doing honor equally to the skill of Mr. Borda, one of our most successful amateur photographers, and to the fine qualities of the lens. Mr. Borda also spoke in high terms of the ease of management, rapidity of working, and satisfactory performance of the lens. There were also exhibited on the same occasion, a num-

ber of large glass positives (shown with the large lantern having 8-inch condensers usually employed at the Institute meetings), of architectural subjects, of an excellence and beauty which we have never seen equalled.

When the first description of this lens appeared in a report of the Secretary of the Franklin Institute, published in this *Journal*, Vol. LII., p. 63, many of those interested in the manufacture and sale of other lenses, were loud in their ridicule of the whole affair as an impossibility, or a valueless device. Among these, the most prominent were the editors of the *British Journal of Photography*, who devised many "demonstrations" (which were no doubt convincing to themselves), that such a lens as we had described must require adjustment after focusing, and could not take a sharp picture.

From the following statement, published in their issue of Dec. 6th, 1867, we presume that they have reconsidered their conclusions.

"**Photographs produced by the Zentmayer Lens.**—We are indebted to our friend, Mr. M. Carey Lea, for a couple of fine photographs; one, a purely architectural subject, the other being as purely landscape. Although they are taken with a lens which is composed of only crown glass, yet the sharpness is quite equal to that of any we have seen by achromatic combinations of the usual kind; indeed, the limit to the appreciation of more detail seems to be the granularity of the paper, when viewed under a strong magnifier."

One energetic opponent has thus, we find, attained to knowledge and appreciation, and another, as we shall soon see, proves in a different way a like result.

Those interested in the globe lens, were in the first case, quite as skeptical as our English friends on the same subject, and though they did not commit themselves to print, yet did to paper to a like effect. But somehow, the Zentmayer lens did keep taking admirable pictures without adjustment of focus, and in fact, proved itself a great success and triumph of skill. Under these conditions, a Mr. C. B. Boyle, of New York, published a letter in the *Philadelphia Photographer*, October, 1867, claiming priority of invention. His claim was answered by us in the same journal for November. To this came a reply from Mr. Boyle in the January number, in which were published drawings stated to be reductions from his own and Mr. Zentmayer's patents. On comparison with the origi-

nals at the Patent Office, these drawings were found to be incorrect in several particulars, by which they were made to resemble each other, and this fact was accordingly published in the *Philadelphia Photographer*, March, 1868. Since this time, Mr. Boyle and his friends have left no stone unturned to worry Mr. Wilson, the editor of the above well known journal, into publishing some species of withdrawal or counter-statement to this exposure. These efforts have, however, proved fruitless.

It is therefore without surprise, that in a late number of *Humphrey's Journal*, which was sent to us, we find a large part of the pamphlet filled with abuse of Mr. Wilson. The authors of these discreditable personalities are in the first place, the editor of the journal and Mr. C. B. Boyle, before mentioned.

With regard to all readers of *Humphrey's Journal*, we should consider no answer needed to these attacks; their spirit and value would be justly appreciated, but as we have occasionally seen extracts from it in a foreign publication, which, feeling little kindness to this country, prefers to show to its readers our worst specimens, we insert for the benefit of our foreign friends and supporters a few words, which may put them on their guard, should the article be reprinted.

The charges contained in this paper are many of them simply childish slanders, such as an accusation of embezzlement of funds, for which a full account has been rendered and published. But there are others on which it may be worth while to speak. Thus, Mr. Wilson is accused of great unfairness in refusing to publish certain letters by Mr. Boyle, in which he sought to defend himself against a charge of publishing false drawings.

The reason why these letters were refused, we know positively, was simply this: The drawings *were* false, as is demonstrated by Mr. Boyle himself, in the article now noticed, (in which he gives one of his former drawings, and one reduced by photography from the same original, which are obviously unlike;) and the letters sent to Mr. Wilson were exactly similar in style and personality to that now published in *Humphrey's Journal*, and therefore obviously unfit for Mr. Wilson's magazine.

One word more. A report has been published by the New York Photographic Society, exonerating Mr. Boyle from the above charges. We have seen the original draft of this report, which was presented to the Society and acted upon. *It is in Mr. Boyle's own*

hand writing. The names of the committee having this matter in charge, have never been published, although the fact that a *committee was appointed*, is on record. In the meantime, we have in our hands certified copies of the original drawings and the published reductions, which are obviously unlike.

We, ourselves, having aided in opposing Mr. Boyle's claims, have been soundly abused, but we bear no malice on that account, and believe ourselves to be actuated in writing the above simply by regard for the cause of truth, and for a friend whom we have long known and respected.

ASTRONOMICAL DISCOVERIES.—Comets in the Spectroscope.—Brosson's comet, discovered in 1846, missed at its perihelion passage in 1851, seen in 1857, again missed in 1862, has been re-discovered in the present year, and submitted by Mr. Huggins to spectrum analysis with the most interesting results.

The two former comets which were examined in this manner by Mr. Huggins, showed from their nuclei luminous bands, closely resembling those of the gaseous nebulæ, while their comœ appeared to shine by reflected sunlight, giving only a subdued solar spectrum.

In the present case, however, the bright lines, three in number, and resembling those found by Donati in his own comet, are not confined to the nucleus, but are due also to the light from the coma, at least in its brighter parts.

In one of these bands, two bright lines were occasionally detected shorter than the bands, and therefore referable to the nucleus. A very faint continuous spectrum was also visible. It thus appears that nearly the whole coma of this comet is self-luminous, which, if it were possible to add anything to the intricacy of the question, What is a comet? adds its mite.

Proper motion of Stars measured with the Spectroscope.—That part of this motion which consists in the approach or recession of the star with reference to the observer, has been measured by Mr. Huggins in the following manner. The amount of refraction which a ray of light suffers, varies with its wave length. Thus, the violet waves of short stretch are much more refracted than the red ones, which are longer. If, then, by reason of a motion either in the earth or a star, the observer is carried towards the source, the apparent length of the waves will be diminished, and they will be more refracted; if, on the contrary, the star and earth are receding,

the waves will be relatively lengthened. Such a motion or change would cause the lines of the spectrum to be displaced, as compared with those in light from stationary sources. By observations based on these principles, Mr. Huggins finds that the nebulæ are neither approaching or receding, at an appreciable rate, and that the star Sirius is approaching our system at the rate of twenty-nine and a half miles per second.

This recalls an observation lately published, that when two trains are passing at speed, the note of the whistle sounded by one and heard in the other is higher on approaching, and lower after passing, than when at rest, or exactly opposite.

Spectra of Nebulæ Compared with Hydrogen.—Mr. Huggins and Father Secchi have found that when the spectrum of the electric spark was enfeebled by distance, it lost all its lines but the double one, which agrees in position with that observed in the nebulæ.

Spectra of Sun Spots.—Mr. Huggins repeating Mr. Lockyer's observations, finds that most of the dark lines are wider in the spectrum of the unbra than in that of the bright surface.

Eclipse.—The expedition sent to India to observe the Solar Eclipse of August, have reported by telegraph that they have met with great success and that the appearances shown in the spectroscope prove the luminous clouds seen around the sun, during total eclipse, to be gaseous.

Editorial Correspondence.

LETTER FROM MR. LATROBE.

PROFESSOR HENRY MORTON,

Editor of the Journal of the Franklin Institute:

Dear Sir:—I notice in the July number of the *Journal* just issued, some editorial references to the "Hoosac Tunnel," to which I must ask your attention, as they (no doubt undesignedly on your part,) place me in a position not altogether agreeable, the spirit of the remarks being likely to be misconstrued by your readers. Thus you speak of the success of the drilling machine, which soon fol-

lowed the recommendation in my report of December, 1866, that its further improvement should be prosecuted *outside* of the tunnel, which should meanwhile be driven by hand labor, as a "good joke" doubtless relished by my friends, &c. The meaning of this may seem to be, that while a young engineer might be excused for a want of foresight, such as was displayed by the failure in this case to see that success was so close at hand, in an old member of the profession it was scarcely pardonable. Now, if my report be referred to, it will be seen that, while giving the history of the drill at the Hoosac Tunnel up to that time, and the reasons for and against it as a labor-saving machine derived therefrom, I do not cast any doubt upon its ultimate success, nor even predict a lengthened period of trial before an effective machine would be secured.

Previous experience in the history of the power-drill, now going back twenty years or more, had shown but a succession of abortive efforts to make it a really useful and economical piece of mechanism, and I was not unwarranted in fearing that its past history might, to some extent at least, be repeated. I can scarcely then be found fault with, because success was so much sooner realized than there was reason to hope? It may be said that the Mont Cenis drill had already demonstrated a performance in Europe, which I should have known could as well be accomplished in America; but we had no right nor indeed the ability to use that precise machine here, for want of acquaintance with the minutiæ of its mechanism; and even in the absence of these difficulties, a feeling of national pride, and an ambition to devise something better, would have stood in the way of a servile copy of a foreign invention. I think, in short, that no one can read the remarks of my report of 1866, on this subject, without agreeing that the "joke" indulged in at my expense, is hardly legitimate, however innocently meant.

Again, it is inferred, that I am not a reader of the *Journal of the Franklin Institute*, because I was not aware at the time of my notice of the Michigan drill, in my recent report of 1867, that this drill was invented by Professor De Volson Wood, a conclusion drawn from very slight premises, as I think you will yourself admit. The fact is, that when I wrote this report, I had just returned from Europe, had been but once at the Tunnel, and the mechanic who showed me the drill only knew that it came from Michigan, without knowing the name of the inventor. Hence, I spoke of it as I did, and I may add that my mention of it was sufficiently favorable

to draw a letter from Messrs. Robinson & Wood, thanking me for the terms in which I had referred to it, and this led to some further correspondence, in which the causes (for none of which I could be held accountable), why the drill had not been allowed a fuller and fairer trial, were adverted to. As to my reading of the *Journal*, to which I have been a subscriber for very many years, and of which I have a complete set back to its first number, I must admit that occasionally, during long absences, certain articles do escape my attention, and among them, it so happened, was Professor Wood's upon the Hoosac drills, which appeared while I was abroad last year, and to which pressure of business on my return prevented me from going back. I presume that I am, on the whole, as regular a reader of the *Journal* as most of its subscribers, if I am to judge from what I hear from others in my profession; but I must allow, as will every fully occupied engineer, that to accomplish the perusal of even half the scientific periodicals of the day is no easy task, and therefore often imperfectly performed.

The differences of opinion between myself and one of the tunnel commissioners are spoken of in the editorial referred to, without any decided intimation as to who is right and who is wrong, but it is admitted that I have *shown* that the contract system recommended by myself has proved the most economical, and that the Legislature of Massachusetts has fully adopted my views on that point, is manifested by their recent abolition of the "commission," and by the requirement that no work after the 1st of October next shall be done upon the tunnel, except under contracts, proposals for which are now being received. In respect to the *pump* question, I have simply to say that I adhere to my opinion of the superior safety and economy of the Cornish engine, at the *top* of the shaft. The donkey pumps (as they are familiarly called), advocated and used at the *bottom* have indeed *luckily* kept the water from causing an absolute suspension of the work, because it has, thus far (contrary to every reasonable expectation), rather diminished than increased in its flow; but it has been more than once on the very verge of drowning the donkeys, to say nothing of the enormously increased consumption of coal, costing $7 per ton, which they have required. It might not be difficult to show that, owing to the difference in this item, and in the repairs of the machines, the Cornish engines would have proved in less time than their services would have been required, *had they been applied at the proper time*, that notwith-

standing their greater first cost, they would have been the *cheaper* as well as the safer and more certain means of draining the tunnel.

I must ask, my dear sir, that you will let these remarks appear in the *Journal*, as much for the purpose of giving a correct account of the present state of affairs at the Hoosac Tunnel, as in explanation of what may seem to require it in my reports as its consulting engineer.

I am, very respectfully yours,

BENJ. H. LATROBE.

North Adams, Mass., August 12, 1868.

LETTER FROM THE ABBÉ MOIGNO.

Paris, September 1, 1868.

M. Hempel, the celebrated constructor and improver of philosophical instruments, to whom we owe great progress in electrical and pneumatic machines, delicate balances, &c., in following up an idea suggested to him by Professor Plücker, of Bonn, has greatly improved upon the apparatus known as the polarizer of Nuremberg. In the form that he has constructed it, the polarizer is composed of:— 1. A blackened glass, placed ordinarily horizontal, or more or less inclined at will, on which the incident ray is polarized by reflection. 2. A disc or ring, placed so as to support, on the path of the reflected polarized ray, the transparent plate which is to show the chromatic polarization. 3. A convex lens, which renders the ray, proceeding from the transparent plate, either parallel or convergent. 4. A new contrivance, which gives to the instrument an unexpected success, a parallel mirror of glass silvered on its exterior surface, fixed at such an angle, on a support, that it brings up to a vertical line the ray, doubly reflected and transmitted, and sends it into a Nicol's prism, which serves as analzyer, and turns on an axis. Whatever be the action exerted by this second mirror, all we can say is, that the phenomena of chromatic polarization, seen in this new instrument, are presented with incomparable intensity and sharpness of outline. For example, a model of a butterfly, formed of thin plates of selenite, of different thicknesses, presents by turning the analyzer, not only the two complementary colors red and green, orange and blue, yellow and violet, of well known polarizers, but all the shades of the spectrum, which succeed one another, with incredible clearness and brilliancy.

In order to demonstrate to the public at large, the visible rotation of the earth by Foucault's well known pendulum experiment, M. Maumené, in 1851, with the sanction of the late Cardinal Gousset then Archbishop of Reims, erected a large pendulum in the cathedral itself, and the experiments were several times repeated with the greatest success.

Now, Monsiegneur Landriot, present Archbishop of Amiens, has just authorized M. Maumené to reproduce in the cathedral of Amiens the same experiments that he made seventeen years ago in the cathedral of Reims. While we write, the preparations are being made with every care, and as speedily as possible, and M. Maumené, who constructed the Reims pendulum with his own hands, is having the same instrument erected at Amiens. He is ably assisted in this interesting work by M. Dubois, professor of mathematics, and M. Poiré, professor of physical science. The ball of the pendulum, without the envelope, weighs about forty-three and a half pounds. The suspending cord is of steel, and is upwards of 164 feet in length, the available height inside the Amiens cathedral being 165 feet. The diameter of the circle of oscillation is to be nineteen feet five inches. Under these conditions, spectators can be convinced by eyesight, on watching the motion of the pendulum, for only half an hour, that the earth does go round on its axis and no mistake.

F. MOIGNO.

THE REWARD OF GENIUS.

THERE is no market for genius. To conduct such a market requires the highest order of talent, combined with a full purse at the outset; and as the two are rarely combined, genius must go begging, or be dependent on slight favors, when it often possesses that, which, after its death, is found to be worth millions to the community. And this will ever be: so long as genius continues ahead of its time, it necessarily leaves those who are incompetent, so far behind.

New discoveries or inventions are not saleable until they are understood; and to have it known, it must be taught, which requires often repeated explanation and frequent illustration, consuming nearly all the time of the man of genius, which is generally spent without any equivalent. Great truths, like great medicines, are sometimes quite sharp and unpalatable. T. S.

Civil and Mechanical Engineering.

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

By G. S. Morison, C. E.

(Continued from page 105.)

Construction of the Web.—The simplest form of web is a thin sheet of metal extending from chord to chord, as in I beams, and the different varieties of plate girders; but the action of the strains within such a web is but imperfectly understood, and so great an excess of metal is required to prevent buckling as to render it, except in very small structures, far from economical.

The function of the web is to resist the shearing strains by conveying the weight applied at each point to the supports. This will be effected by a series of bars running from chord to chord, and thus connecting the ends of the beam by a zigzag line. A weight applied at any point of the truss will travel on these bars from chord to chord, and so reach one of the supports. As weight always exerts a downward force, the bar on which it travels from upper to lower chord will be strained in compression, and that on which it travels from lower to upper chord in tension.

The bars may be so arranged that the load shall advance towards the supports when travelling from upper to lower chord, when travelling from lower to upper chord, or in both cases. In the first case, the tension bars or ties will be vertical, and the compression bars or struts inclined (Fig. 12); in the second case, the struts will be vertical, and the ties inclined (Fig. 13), and in the third, both struts and ties will be inclined. (Figs. 14 and 15). The first arrangement is that adopted in the common Howe Truss, the second that of the Pratt Truss, and the third in which struts and ties are equally inclined, that of the Warren Girder. The bracing of the web may also be arranged in two or more systems (Figs. 16, 17, 18 and 19). In this case, each system bears its own share of the weight independently of the others. Fig 19 is simply a Warren girder developed into a lattice.

FIG 12

FIG 13

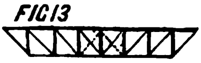
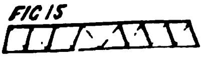


FIG 14

It may be noticed that in an open truss, any rupture due to the

shearing strain would extend through the length of a panel, which would thereby be distorted. That this is precisely analogous to the sliding of one part upon another in a solid beam, will appear from Fig. 20.

FIG 15



Through that part of the beam in which the shearing strain is positive, the weight must be conveyed to the left hand support, the struts, if inclined, will then lean to the right, and the ties to the left; when the strain is negative, the weight is to be carried to the right hand support, the struts leaning to the left, and the ties to the right. As the sign may change anywhere between s and s′, Fig. 11, between these two points the web must be capable of carrying the strain in both directions. This will be effected in the first and second arrangements of web by introducing counter-bracing, as shown by the dotted lines in Figs. 12 and 13; in the third arrangement by making the bars of the central panels capable of acting both as struts and ties; in that arrangement in which the ties and struts are inclined unequally, either method may be used.

FIG 16

FIG 17

FIG 18

FIG 19

The distance on either side of the centre to which counter-bracing need be carried, can be calculated by the formula already given, and is dependant solely on the ratio between the dead and moving loads. Table I. gives the distance in decimals of the whole length of the truss, through which counter-bracing is needed on each side of the centre for several values of this ratio. It can rarely happen that the dead load will be as great as in the three or four values at the head of the column, but they serve to show how slowly the length of counter-bracing decreases in heavy bridges, and how little stiffness can be gained by the expensive plan of ballasting. When the point s falls between the centre of a panel and the end of a truss, no counter-brace is needed in that panel, but it is well to put one in as a precaution against the possibility of an excessive load. Beyond this limit, counter-bracing, unless used as in the Post and McCallum bridges, to create an artificial stiffness, is abso-

FIG 20

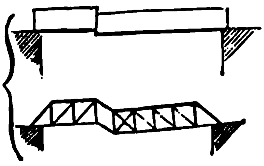
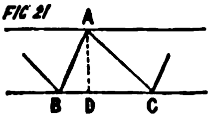


FIG 21



lutely useless, the strain on the main brace necessarily throwing the counter out of adjustment.

In determining the most economical arrangement of the bars composing the web, the relative inclination of struts and ties, and the length of panel must both be examined.

I. To find the most economical relative inclination of struts and ties. In Fig. 21, let BA represent a strut, and AC a tie, then

AD $= a =$ depth of truss.

BC $= b =$ length of panel.

BD $= c =$ inclination of strut.

DC $= b - c =$ " " tie.

$$AB = \sqrt{a^2 + c^2} \qquad AC = \sqrt{a^2 + (b - c)^2}$$

By varying c between 0 and b, Fig. 21 will be made to embrace the several arrangements of Figs. 12, 13 and 14.

TABLE I.

Ratio of dead to moving load.	Length of counter-bracing on each side of centre.
10	·012 l
5	·023 l
4	·028 l
3	·036 l
2	·051 l
1·8	·055 l
1·6	·060 l
1·4	·067 l
1·2	·075 l
1·	·086 l
·9	·092 l
·8	·100 l
·7	·109 l
·6	·120 l
·5	·134 l
·4	·152 l
·3	·176 l
·2	·210 l
·1	·268 l
0	·500 l

The strains in the braces being produced by a force acting vertically, will be proportional to their lengths, and if m denotes the weight or value of a section of the strut capable of sustaining a unit of strain, and n the corresponding section of the tie, then the weight or cost of the strut is proportional to

$$m\,(a^2 + c^2)$$

and that of the tie proportional to

$$n\left(a^2 + (b - c)^2\right)$$

and that of the two braces proportional to

$$m\,(a^2 + c^2) + n\left(a^2 + (b - c)^2\right)$$

The minimum value corresponds to the case when the differential co-efficient taken relatively to c vanishes, or

$$2\,m\,c - 2\,n\,(b - c) = o$$
$$c = b - c = n : m$$

Hence the most economical division of the panel is that which makes the inclination of tie and strut, in the inverse ratio of the weight or value of material required in each to sustain a unit of strain.

II. To find the most economical length of panel. The whole

material in the web is in the direct ratio of the material in each panel, and the inverse ratio of the length of panel, and proportional to

$$\frac{m(a^2+c^2)+n\left(a^2+(b-c)^2\right)}{b}$$

For the first arrangement (vertical ties), $c=b$, and this fraction becomes

$$\frac{(m+n)\,a^2+m\,b^2}{b}$$

which is a minimum when the differential co-efficient taken relative to b vanishes, or when

$$m-\frac{(m+n)\,a^2}{b^2}=o$$

$$b=a\sqrt{\frac{m+n}{m}}$$

in which case the whole material in the web is proportional to

$$2\,a\sqrt{m\,(m+n)}$$

For the second arrangement (vertical struts), $c=o$, and the web is proportional to

$$\frac{(m+n)\,a^2+n\,b^2}{b}$$

and this is a minimum when

$$b=a\sqrt{\frac{m+n}{n}}$$

the whole web being then proportional to

$$2\,a\sqrt{(m+n)\,n}$$

For the third arrangement (ties and struts equally inclined), $c=\frac{1}{2}\,b$, and the web is proportional to

$$\frac{(m+n)(a^2+\frac{b^2}{4})}{b}$$

and this is a minimum when

$$\tfrac{1}{4}-\frac{a^2}{b^2}=o \qquad b=2\,a$$

the web being then proportional to

$$a\,(m+n)$$

(To be continued.)

STEAM-ENGINES OF THE FRENCH NAVY.

BY R. H. THURSTON, U. S. N.,

(Member of the Institute.)

A PECULIARLY ingenious modification of the "Woolf system" of steam-engines has recently been extensively introduced into the French iron-clad navy, with the expectation of securing a marked economy in consumption of fuel and other advantages.

In this design, three cylinders of equal size are set side by side, and coupled to the same crank-shaft. These cylinders are precisely alike in every part, and their pistons, rods, and valve gear are all cast from the same patterns, and forged from the same drawings, and the distribution of steam is ingeniously arranged in such a manner as to throw nearly equal work upon each cylinder, the high pressure cylinder receiving the same maximum strains as the low pressure cylinders.

In the first of these designs, the cranks were set at angles of 120° with each other. The steam, moderately superheated, passed through the steam jackets of the two condensing cylinders, and entered the high pressure cylinder which was placed between the other two. In the high pressure cylinder, steam followed the piston until the crank had swung through 120° of arc, when the valve closed the steam port of the middle cylinder, which we will call A, and at the same instant, a condensing cylinder, B, commenced taking steam from A, the steam expanding in both cylinders.

As A commenced its return stroke, it would compress the steam remaining in A, but at that time, the piston of the condensing cylinder, B, travelled so much more rapidly than that of A, that it compelled a continued expansion; when the crank of B had passed over 120°, or when that of A had moved through 240°, B closed its steam port, and the other condensing cylinder, C, took steam from A, until the latter reached its dead point; there the valve of C closed its port, while A took steam again. A reservoir was at first interposed between the high pressure and the condensing cylinders, into which the steam was exhausted from A, and from which the other cylinders took their steam. It was found to have no useful effect, and was afterwards removed.

In later engines, the cranks of the two condensing cylinders are set at an angle of 90° with each other, and that of the high pressure cylinder 135° from either, while the point of cut-off is fixed at

or within half stroke for the high pressure, and at three-quarters for the condensing cylinders.

Figs. 1 and 2 exhibit the pressures on one side of the piston, in each cylinder, during a complete revolution, in each of these styles of engines.

The full lines *a a a a* represent the pressure in the middle cylinders, and the broken lines show the pressure in the condensing cylinders, the ordinates representing the pressures, and the abscissas measuring degrees of arc.

L L is the line of atmospheric pressure; the dotted line exhibits the back pressure in cylinder A, and affords a ready means of comparison of the amounts of work done in each cylinder. The back pressure line of the condensing cylinders is taken at 13½ pounds below the atmosphere. It will be noticed that in the later engine, whose curve is given as Fig. 2, steam enters cylinder A from the boiler, until the crank has passed over 90°; from 90° to 135° steam expands in A; from 135° to 225° it expands in A and B; from 225° to 255° it expands in A, B and C; from 255° to 345° it expands in A and C, and is compressed in A during the last 15° of the revolution.

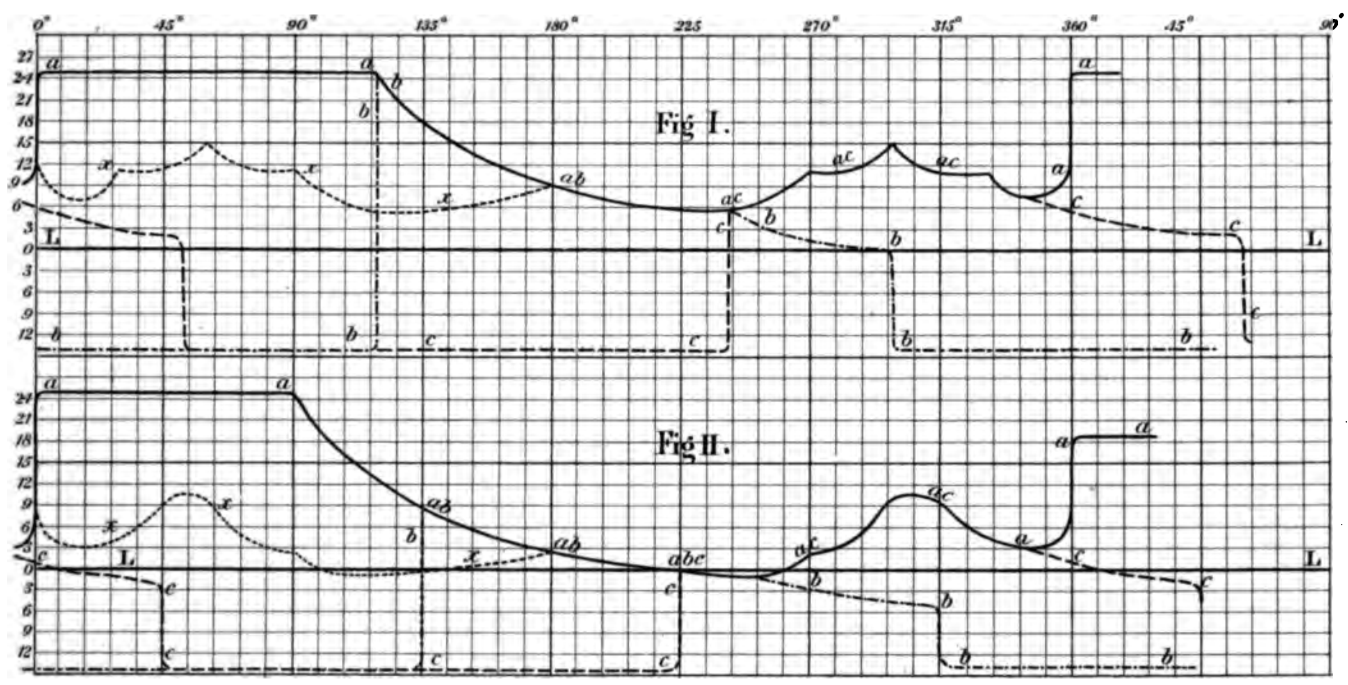
The amounts of work done in the several cylinders are very nearly equal, and the *maximum* pressures on the crank pin are almost precisely the same.

It will be noticed that at some portions of the revolution, where steam is expanding in the middle cylinder and one of the side cylinders simultaneously, the full line of the middle cylinder *a a a* coincides with and hides the broken lines *b b b* and *c c c* of the side cylinders.

The designer claims for this engine superiority in economy of fuel, nearly perfect static equilibrium, great length of bearings with moderate pressures upon them, and economy in first cost and in repairs.

Engines of this pattern were exhibited at the Paris "*Exposition*" of 1867, and attracted much attention from engineers who have looked with interest for reports of performance.

Those engines, intended for the *Friedland* and the *Ocean*, were of 82⅝ inches diameter of cylinder, 4 feet 3¼ inches stroke, and drive a Mangin screw of 20 feet diameter, and 28 feet of pitch; they were rated at 960 nominal horse-power, and were intended to work up to 4,000 indicated horse-power; their weight was about 400 tons, and



Lith. Jas. McGuigan Philada

with boilers ready for steam, something over 800 tons; their cost was about $300,000, gold.

They were intended to drive iron clads of 7,000 tons displacement 14½ knots per hour; their duplicates have not worked up to as high a power as was intended, but a speed of 14·2 knots is claimed.

In 1863 a board of officers was directed to conduct a series of experiments with the engines, then just completed from the new designs, for the *Loiret*, and to report upon the relative economical value of the old plan with two cylinders and the new style.

The experiments, seven in number, of twelve hours each, exhibited an economy of from 3 to 7 *per cent.* in favor of the new engine.

The result for the two cylinder engine was obtained by simply removing the valves from the middle cylinder, thus using the two condensing cylinders under some disadvantages, and probably appreciably exaggerating the relative value of the new design.

The Board reported that they considered it advisable to make a trial of an engine with three cylinders, but each taking steam direct from the boilers, in competition with the *Loiret* engine.

Such engines were accordingly fitted to the iron clads *Gauloise* and *Revanche*, and their performance compared with engines of the new type fitted to the iron clads *Magnanime*, *Savoie* and *Valeureuse*.

The vessels were all similar, displacing 5,711 tons; their length was 262½ feet, breadth 56 feet, and draught of water 25½ feet; their engines were intended to develop 4,000 indicated horse-power.

The engines of the *Gauloise* type cost *two-thirds of one per cent. less* than the *Savoie* style.

The following table exhibits the result of their trials:

Name.	Engine Builder.	Date.	Style Engine.	IHP.	Coal per H. P. per hour.	Press. Steam.	Saturation.	Rev.
Gauloise	Mazeline	Aug. 1867	Three Independent Cylinders	3,639	3·02	16½	2·57	56·3
Revanche	Forge et Chantiers.	July, 1867		2,554	3·33	13½	......	52·
Magnanime	Mazeline	June and July, 1866	Dupuy de Lome's Modification of the "Woolf System."	3,506	2·85	29	......	54·26
				3,326	2·83	28	2·43	54·
Savoie	Forge et Chantiers	May, 1866		3,197	3·57	30	......	54·1
Valeureuse	Indret	Aug. 1867		3,467	3·10	27	2·42	55·4

The point of cut-off in the *Gauloise* engines was fixed at *four-tenths;* the *Magnanime* expands about four times.

Neither of these engines worked up to its intended power, and neither exhibited surprising economy of fuel, the two styles being about equal in that respect.

A member of the Board which has been mentioned, has recently published a pamphlet in which he analyses the claims advanced by M. Dupuy de Lôme, in a "*Note*" to the *Revue maritime et coloniale*, and his ideas accord so well with those of many of our own engineers, that we translate in full his

CONCLUSIONS.

Comparing this new engine—derived from Woolf's system—with the ordinary engine with two cylinders, we see by experiments before referred to, that the latter (under exceptionally disadvantageous conditions, however, as in the *Loiret*), exhibits from 3 to 7 *per cent.* greater consumption of fuel, a fault slight in itself, and which is certainly more than compensated, *for a war vessel*, by the advantage of employing for the same number of revolutions of the screw, a much lower pressure in the boiler, and, consequently, of being less exposed to incrustation, which takes place so rapidly at high temperatures, and of being less liable to dangers that accompany ultimate rupture, and by the further advantage of being able to steam at much lower speed, if it is desirable not to reduce the pressure.

The *maximum* strains upon the crank-pins are greater in the engines with two cylinders. However, they are not *double* as the author of the "*Note*" asserts; the difference is only about *ten per cent.* On the other hand, the uniformity of the "couple of rotation" is more satisfactory in the engine with two cylinders; the latter, at lower cost, is of less weight, and occupies less space, thus presenting an important advantage where excessive thickness and weight of armor-plating interpose such great obstacles to the full and *effective* protection of the vital part of war vessels.

Since the working pressures are very different in the two styles of engines, developing the same power, it follows that, as the boilers deteriorate and it becomes necessary to reduce the pressure, this reduction will be a greater disadvantage to the new engine than to the engine with two cylinders, as it will affect the former only until the working pressure of the engine with two cylinders is reached, during all of which time its power will decrease, while the two-cylinder engine will retain its power.

We see then, by comparison of the respective advantages and disadvantages of the two engines, that the superiority attributed by its designer to the new machine over that with two cylinders, is perfectly debatable.

But if we compare the new engine of the *Savoie* type with the engines with *three independent* cylinders of the *Gauloise* type, we may conclude, from the preceding discussion, that the *latter* are in every respect superior.

In fact: 1. They are equal to the other in respect to economy of fuel, and besides, they have, with less, by 12 pounds, boiler pressure, worked up to a power greater by nearly 400 horse-power.

2. They afford greater security on approaching a high velocity of rotation, because their "couple of rotation" is more regular, their maximum pressure on their bearings is 50 *per cent.* less, and because the cutting caused by high temperature of steam is less to be feared.

3. The statical equilibrium of their reciprocating parts is more perfect from the more regular manner in which the cranks are set on the shaft.

4. To obtain 4,000 horse-power with these engines, a lower velocity may be adopted than is proposed for the engines of the *Friedland*, by raising the pressure, without, however, approaching 26 pounds, or by extending the introduction, while with the *Friedland's* engine that power cannot be obtained, unless by exceeding the working pressure—26 pounds—or by increasing the velocity of rotation, which is already too great.

5. Finally, as the point of cut-off in the *Gauloise* type is only at ·40, when the boilers become worn, a lower pressure may be used without lessening the power, by allowing the steam to be cut off later; this would be impossible with the new engine, where the introduction is already at its maximum.

En résume, the three advantages attributed to the new engine by its designer, in comparison with the engine of two cylinders—which advantages we have reduced to their true value—become, on the contrary, so many points of marked inferiority in comparison with the three cylinder engine of the *Gauloise* type, which latter possesses the highly important advantages referred to in paragraphs 4 and 5 above.

This engine, on the modified Woolf type, is therefore far from exhibiting an "important advance" as the author of the "*Note*" announced.

In fact, its greatest defects may pass unnoticed in time of peace, because those occasions on which the engines of our war vessels are required to develope all their power, are then very rare and of short duration; but in time of war, for which those vessels are constructed, a speed that calls for high pressures and speeds of piston, will be often demanded and obtained. Then the great dangers that these engines bring with them will be made evident.

In presence of such contingencies, there will be no hesitation in altering these engines as promptly as possible into machines of the *Gauloise* type, which can fortunately be done without difficulty.

The latter style of engine has been introduced into the English navy, and the *Loiret* commission, in recommending it, in 1863, in preference to that which the "*Note*" would have us accept to-day, pointed out to the administration one of the best courses that it could pursue.

It was this that we have attempted to prove, and we believe that we have offered full evidence of the fact.

(Signed) H. LABROUSSE.

Since the date of the above criticism, the French engineers have definitely adopted surface condensation in the new type of engine, with a view to the avoidance of the rapid deposit of incrustation due to the higher pressure, but the other objections remain and will probably prove fatal to this style of engine, in spite of the advantages it possesses of equalizing and lessening the strains upon the bearings, reducing initial high pressures where high steam is used, and affording large bearings, as well as the economical advantage of similarity of parts in its several cylinders and their appurtenances.

Providence, R. I., July, 1868.

CUTTING AND PLANING STONE.

BY S. W. ROBINSON, C. E.

MANY attempts have been made to dress stone of various kinds by the action of a cutting tool passing over them, as in planing or turning iron, wood, &c. Very many of these attempts have failed mainly for the reason that the grit of most stone will not admit the passage of any tool, which can be economically used, without its

suffering too severely from the grinding action of the stone. Nothing but the diamond can act in this manner upon stones, which are most difficult of being so cut, such, for example, as granite, quartz, &c. But the diamond is too expensive for common use.

Other varieties of stone, such as gypsum, soapstone, slate, &c., are, on the contrary, easily cut with a steel-tool in the manner above described. Limestone is more difficult; and sandstone, even if it be softer, is yet less easily cut on account of the grit. There is, therefore, a certain limit beyond which this mode of acting upon stone must cease

It is well known that blows upon a steel tool, when in contact with a refractory stone, will flake off particles without seriously injuring the cutting edge. This is the mode of action of the common drill in boring blast holes; also of the stone mason's dressing chisels. This principle for cutting stone may also be brought into action by rolling a circular cutter, under heavy pressure, over the surface of the stone. The cutter being free to revolve, so as to relieve its edge from slip, presents a sharp edge to the stone throughout its whole periphery. A very hard steel cutter may thus be made to act upon glass, leaving heavy traces to mark the passage of the tool.

A combination of the two methods of cutting above described, has been tried for cutting stone which could not be cut by the first named process. Near the eastern portal of the Hoosac Tunnel, in Massachusetts, may be seen a hole about 16 feet deep, horizontally, and 24 feet in diameter, which was bored into the solid talcose slate of the Hoosac Mountain by an immense tunneling machine in the earlier days of the present Hoosac Tunnel enterprise. The surface of the rock, as left by this remarkable machine, is as smooth as though dressed to an even cylindrical surface by masons' chisels. The machine which did this work was provided with revolving cutters, the axes of which were set diagonally to the path of their motion, so that the cutting was due partly to the rolling contact, and partly to slip. This machine was unsuccessful, as is shown by the fact that it was intended to bore through the mountain, but only made about 16 feet advance before being abandoned on account of the expenditure of one set of the circular cutters, which were very costly. A tunneling machine was tried in England which cut its way 80 feet into rock, but was not regarded as successful.

At Lemont, Ill., may be seen a massive planer, constructed of

iron, on which immense flagging and facing stone are planed to a remarkable degree of smoothness, presenting, in fact, almost a polished surface. The stone thus treated is limestone, from the magnesium limestone beds in the vicinity of Lemont, from which many of the excellent building stone of the city of Chicago are quarried. The stone to be dressed is purchased at the quarries by A. T. Merriman & Co., planed, and sold at an advanced figure. The stone is planed in a manner similar to that of planing iron. A series of cutting tools are fixed, under which the stone moves to and fro with a great degree of power and steadiness, the cutters taking off shaving after shaving until the desired quality of surface is obtained. The edges of the stone are also squared down, and grooved to receive an iron tongue to break joints, and cause the fronts of any two or more consecutive stones to lie in the same plane. A very slow speed is required to plane this limestone in order to preserve the cutting edges of the tools for any considerable length of time. This limestone is quite hard, and figures among the strongest of building stone, but having less real grit than many other kinds of stone is still susceptible of being reduced to shavings by steel tools and skilful management.

Sandstone, from which grindstones are produced, being very gritty, can best be turned and dressed for the market by tools which are changed into various positions by special manipulation, as they are ground away, so that a sort of rude cutting edge is being continually formed and brought to bear upon the the grit. This method of procedure is adopted at the works of Barea, Ohio.

A very good tool for renewing the surface of grindstones by turning, when worn by use, is simply a round rod of soft iron about one-fourth or three-eights of an inch in diameter. Having provided a rest as near to the revolving stone as practical, the rod may be presented nearly perpendicular to its face. By inclining the rod slightly toward the part which is uncut, and rolling it gradually in the same direction while being held firmly, the stone will be reduced by a cutting edge, or rather nearly a point, which has a breadth of only about half the diameter of the rod in contact with the stone. A similar manipulation may be adopted with any very gritty material.

University of Michigan, July, 1868.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

The following rules and data in connection with belts for driving machinery, form part of a collection made by the writer for his own private use, and are here given as a condensed exhibit of the results derived from practical mechanical sources in the more accessible engineering publications, and from machinery now in operation in this city.

The deduction of a simple rule, from the statements given, which shall serve the needs of all cases in practice, may neither be fair nor easy, yet it is believed that a relation exists between the quantity, or properly the *area* of belt in motion and the power transmitted thereby, when under certain conditions, which might be expressed in simple terms, and answer the wants of usual practice. The reader can best judge for himself as to the existence of such a relation in a perusal of the facts which follow.

1. The width of a certain belt is 18 inches, speed of same 1500 feet per minute, angle of belt with horizon 45°, distance between centres of drums 25 feet, diameter of driving drum 8 feet, of driven drum 4 feet.

When this belt transmitted 20 horse-power, it worked quite freely and well, when the power was increased to 28 horse, a tightener had to be applied, which caused the journals of the driven shaft to "heat."

From the above data we deduce the following formula:

$$\frac{\text{HP} \times 3\frac{3}{5}}{\text{Diam. small pulley in feet}} = \text{width of belt in inches.}$$

If we consider this belt as transmitting $22\frac{1}{2}$ horse-power, we shall have a constant travel of 100 square feet of belt per minute per horse-power, assuming the above conditions.—*Appleton's Dict. of Mech.*

2. "An 8-inch belt, running 100 feet per minute, will give one horse-power." This rule is equivalent to the transmission of $66\frac{2}{3}$ square feet of belt per minute per horse-power.

3. An old rule provides 100 square feet of belt per minute for every horse-power, and we have heard it remarked that half that amount was sufficient.

4. "A 12-inch belt, running on a $5\frac{1}{2}$-foot pulley, making 45 revolutions per minute, will carry away 12 horse-power." This rule gives 64·8 square feet of belt per minute per horse-power.

5. A friend gave me the following:

$$W = \frac{350 \text{ horse-power}}{D \times \text{rev. per minute.}}$$

In which W = width of belt in inches.
D = diameter of pulley in feet.

This gives a strain of 30 pounds per inch of width of belt and 91·63 square feet of belt transmitted per horse-power per minute.

6. "A certain 11-inch belt daily transmits from a 4 feet pulley, running 60 revolutions per minute, the power exerted by an 11-inch cylinder, 30-inch stroke, making 45 revolutions per minute under 50 pounds of steam, which, at the usual method of rating, yields 29 horse-power. This belt runs vertically without an idler, and measures 23·8 square feet per minute per horse-power."—*Sci. Amer.*, July, 1865, page 4.

7. "An empirical rule for ascertaining the width of belts that we know to be in use by some good practical men is as follows:"

$$B = \frac{31{\cdot}4\ N}{n\, d}.$$

In which B = width of belt, thickness taken at $\frac{3}{16}$-inch.
N = No. horse-power.
n = No. revolutions per minute.
d = diameter of pulley.—*Lond. Mech. Mag.*, Mar., 1863.

8. "Our engine is a 16-inch cylinder, 24 inches stroke, running 75 revolutions per minute under 80 pounds of steam. Belt 15 inches wide, on driving pulley 8 feet diameter, driven pulley 3 feet higher than the engine shaft, and 24 feet distant, top belt 'slack,' no tightener used and belt never slips."

"We drive with this belt 3 'runs' of stone with all the necessary machinery. Engine is rated at 60 horse-power."—W. R. C. in *Sci. Amer.*, July, 1865, page 36.

This is 39·27 square feet of belt per minute per horse-power at the above rating.

9. "I lately put up a belt 12 inches wide, having a velocity of 800 feet per minute for driving a pair of 54-inch wheat buhrs, 140 turns per minute. I calculate the power at 12 horse. The belt works beautifully. This belt had a tightener pressure of 400 pounds, and runs horizontal."

"We used to put 10-inch belts on 8-foot fly-wheels, of engines which we sold for 12 horse-power, running the belts at 1000 feet per minute."—J. W. H. in *Sci. Amer.*, July, 1865, page 53.

These examples give 66$\frac{2}{3}$ and 69·44 square feet per minute per horse-power, respectively.

10. "At a speed of 1800 feet per minute on pulleys over 36 inches diameter, every 1 inch wide will give 2 horse-power."

This equals 75 square feet per minute per horse-power.

11. "The old rule is 1 inch wide to the horse-power at 1500 feet per minute," which is 125 square feet per minute per horse-power.

12. A certain 6-inch × 12-inch cylinder horizontal engine, with plain slide valve, arranged to cut off at $\frac{5}{8}$ths the stroke, works under 80 pounds of steam, has a 7-inch belt on a 4-foot pulley on engine shaft making 100 revolutions per minute, and drives a 30-inch pulley on the "line" shaft about 4 feet above the cylinder.

A 24-inch pulley on the other end of this "line," carrying a 7-inch belt, with a "half-twist," drove a 10-inch pulley on a shaft about 18 feet beneath the former.

The 10-inch pulley shaft, in its turn, drove a certain machine which consumed more power than the engine was capable of giving.

The result was, the 7-inch belt from the line to the 10-inch pulley, would continue to slip even when very tight and well covered with resin, while the 7-inch belt from the line to the pulley on the engine shaft would hold firmly to its pulleys and stop the engine.—*Writer.*

13. In hoisting the materials for the towers of the Cincinnati Bridge, Mr. John A. Roebling, Esq., used engines of 10 inches bore and 20 inches stroke, making 80 to 150 revolutions per minute, and working under a steam pressure, ranging from 60 to 80 pounds.

The power of these engines is transmitted by a 9-inch leather belt, from a 4-foot iron pulley on the engine shaft, to another 4-foot pulley on the pinion shaft. This pinion is 14½ inches diameter, and drives a 6-foot spur-wheel, on the shaft of this latter is another 14½-inch pinion, gearing into another 6-foot spur-wheel on the shaft of which is secured a 3-foot drum. This drum carries a 1½ inch diameter wire rope connected directly to the loads to be lifted.

A block, weighing 8400 pounds, can be raised at the rate of 50 feet per minute, by pressing the tightener down so that the belt laps on $\frac{3}{8}$ths of the circumference of the 4-foot pulleys.

With a load of 10,200 pounds the belt slips, and its splicings and

safety are endangered by too severe an application of the tightener which is necessary to lift this weight. A load of 8000 pounds may therefore be considered a fair working condition of the belt, which indeed it has endured nearly three seasons without failing.

Blocks weighing 8000 pounds have been frequently raised 150 feet high in two and a half minutes, without slippage of the belt. This speed is equal to 60 feet per minute, and the duty performed is equivalent to $60 \times 8000 = 480{,}000$ pounds $= 14{\cdot}54$ horse-power, speed of belt being 1885 feet per minute.

Quantity of belt running per minute, per horse-power $= 97{\cdot}232$ square feet.—J. A. R. in *Sci. Amer.*, July, 1865, page 68.

14. From Molesworth's *Pocket-Book of Engineering Memoranda*, we take the following:

V = velocity of belt in feet per minute.

H P = horse-power (actual) transmitted by belt.

$$\text{X} = \frac{33{,}000\ \text{H P}}{\text{V}}.$$

S = strain on belt in pounds.

W = width of single belting ($\frac{3}{16}$ inch thick) in inches.

$$\text{S} = \text{X} + \frac{\text{X}}{\text{K}}.$$

$$\text{W} = \frac{\text{S}}{50}.$$

K = ·09, 1·3 and 1·6 when portion of driven pulley embraced by belt = ·40, ·50 and ·60 of the circumference, respectively.

For double belting the width = $\text{W} \times 0{\cdot}6$.

Approximate rule for single belting $\frac{3}{16}$ inch thick,

(*a*.) . . . $\text{W} = \dfrac{1100\ \text{H P}}{\text{V}} = 91\frac{2}{3}$ per square feet per minute per horse-power.

"The formulæ above apply to ordinary cases, but are inapplicable to cases in which very small pulleys are driven at very high velocities, as in some wood cutting machines, fans, &c. The acting area of the belt on the circumference of the driven pulley being so small that either great tension or a greater breadth than that determined by the formula is required to prevent the belt from slipping."

(To be continued.)

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

BY PROF. ALFRED M. MAYER, PH.D.

(Continued from page 119).

10. *Attraction*, 11. *Repulsion*.

ATTRACTION exists between the minute parts or *atoms* of bodies, and they would continually approach, until contact supervened, if they were not kept apart by an equal and opposing repulsion. These molecular attractions and repulsions are often designated as *the molecular forces.*

The phenomena of traction, of compression, of porosity, and of the transmission of vibrations through all kind of matter, prove indirectly that bodies are formed of minute parts which do not touch, but are kept at certain distances depending on the intensity of the attractions and repulsions subsisting between them; while there are many direct proofs of the above statement which will be given further on.

All *masses* of matter mutually attract each other with an intensity directly proportional to their masses, and inversely as the squares of their distances. This tendency is called *gravitation*, and is common to all matter. This is shown in the celebrated experiment devised by the Rev. John Michell, and generally known as the Cavendish experiment for determining the density of the earth. Describe this apparatus.

Electric and magnetic attractions and repulsions also follow the law of the inverse squares of the distances.

The different manifestations of attraction and repulsion may be thus arranged:

GRAVITATION, ELECTRICITY, MAGNETISM,	Which act at sensible distances; *i. e.* beyond the $\frac{1}{2000}$th of an inch,
COHESION, ADHESION, CAPILLARITY, CHEMICAL AFFINITY,	Which act at insensible distances; *i. e.* within the $\frac{1}{2000}$th of an inch.

Molecular Attraction.

Cohesion designates the attraction existing between the minute parts of the same body; *adhesion* the attraction between the parts of dissimilar bodies. Sometimes designated respectively as homogeneous and heterogeneous attraction.

Experiments on *Cohesion of solids.*—Two leaden planes pressed together, cohere with a force of forty pounds to the square inch. Two plates of glass cohere even in vacuo, which shows that the phenomenon is not due to the atmospheric pressure. The intensity of the cohesion in this experiment is proportional to the surface, and increases with the time of contact. In plate glass manufactories, mirror glasses sometimes cohere with such force, from having been placed on each other without intervening paper, that it is impossible to separate them. It is to be remarked that in the above instances only a comparatively few points of the cohering surfaces are in contact.

"There is a precious experiment by Mr. Huyghens in No. 86 of the Philosophical Transactions. A piece of mirror glass being laid on the table, and another, to which a handle was cemented on one surface, being gently pressed on it, with a little of a sliding motion, the two adhered, and the one lifted the other. Lest this should have been produced by the pressure of the atmosphere, Mr. Huyghens repeated the experiment in an exhausted receiver, with the same success.

"He found that one plate carried the other, although they were not in mathematical contact, but had a very sensible distance between them. He found this by wrapping round one of the plates a single fibre of silk drawn off from the cocoon. The adhesion was vastly weaker than before, but still sufficient for carrying the lower plate.

"Here, then, is a most evident and and incontrovertible example of a mutual attraction acting at a distance. Mr. Huyghens found that if, in wrapping the fibre round the glass, he made it cross a fibre already wrapped round it, there was no sensible attraction. In this case, the glasses were separated by a distance equal to twice the diameter of a fibre of silk.

"I said that this experiment showed that it was not the attraction of gravitation that produced the cohesion. I have repeated the experiment with the most scrupulous care, measuring the disance of the glasses (the diameter of a silk fibre), and the weight

supported. I find this, in all cases, to be nearly 14½ times the action of gravity. The calculation is obvious and easy. I tried it in distances considerably different, according to the diameter of the fibre. I must inform the person who would derive his information from his own experiments, that there are many circumstances to be attended to which are not obvious, and which materially affect the result. The silk fibres are not round, but very flat, one diameter being almost double of the other. The 2400th part of an inch may be considered as the average smaller diameter of a fibre. A magnifying glass must be used, and great patience in wrapping the fibre round the glass so that it may not be twisted. A flaxen fibre is much preferable, when gotten single, and fine enough, for it is a perfect cylinder. I must also inform him, that no regularity will be had in experiments with bits of ordinary mirror; these are neither flat enough, nor well enough polished. We must employ the square pieces which are made and finished by a *very few London artists* for the specula of the best Hadley's [Godfrey's] quadrants. These must be most carefully cleaned of all dust or damp. Yet this must not be done by wiping them with a clean cloth; this infallibly deranges everything by rendering the plate electric. I succeeded best by keeping them in a glass jar, in which a piece of moist cloth was lying, but not touching the glasses. When wanted, the glasses are taken out with a pair of tongs and held a little while before the fire, which dissipates the damp which had adhered to them, and which prevented all electricity. With these precautions, and a careful measurement of the diameter of the silk fibre, the experiments will rarely differ among themselves one part in ten.

"* * * * * * If the plates have been hard pressed, with a sliding or grinding motion, the adhesion is then either very strong, or nothing at all; when they do adhere, it seems to be another stage or alternation of the force, as will be explained by and by. But they rarely adhere, owing to fragments torn off by the grinding. The glasses will be scratched by it.

"I thought this capital experiment worthy of a very minute description, it being that which gives us the means of mathematical and dynamical treatment in the greatest perfection." "*A System of Mechanical Philosophy*, by John Robison, L. L. D. Edited by Sir David Brewster, Edinburg: printed for John Murray, London, 1822." Vol. I. page 240, *et seq.*

Cohesion in solids is measured by the force in pounds avoirdu-

pois required to tear apart, by a direct pull, a rod of one square inch area of section. This measure is called the *tenacity* of a body.

TABLE OF TENACITIES FROM "RANKINE'S APPLIED MECHANICS."

Steel	115,000
Iron, wire	95,000
" wire ropes	90,000
" wrought bars and bolts	65,000
" cast	16,500
Copper, wire	60,000
" cast	19,000
Brass, wire	49,000
" cast	18,000
Gun-metal (copper 8, tin 1)	36,000
Zinc	7,500
Tin, cast	4,600
Lead, sheet	3,300
Teak	18,000
Ash	17,000
Mahogany	16,200
Locust	16,000
Oak, European	14,900
" American red	10,250
Fir—red pine	13,000
" spruce	12,400
" larch	9,500
Chestnut	12,000
Beech	11,500
Maple	10,600
Hempen cables	5,600
Slate	11,200
Glass	9,400
Brick	290
Mortar	50

Cohesion of liquids is shown in the force required to separate a disk of wood from a liquid which wets it; this force varies with the liquid, requiring 52 grains per square inch to separate the disk from water; 31 grains for oil of turpentine; 28 grains for alcohol. These experiments, however, as will be seen below, give only the *relative* cohesion.

Prof. Joseph Henry, in a valuable contribution to molecular physics, published in the *Proceedings of the American Philosophical Society* for April, 1844, showed that the molecular attraction of water for water, instead of being only about fifty-two grains to the square inch, is really several hundred pounds, and is

probably equal to that of the attraction of ice for ice. The following are extracts from Dr. Henry's paper:

"The passage of a body from a solid to a liquid state is generally attributed to the neutralization of the attraction of cohesion by the repulsion of the increased quantity of heat; the liquid being supposed to retain a small portion of its original attraction, which is shown by the force necessary to separate a surface of water from water, in the well known experiment of a plate suspended from a scale beam over a vessel of the liquid. It is, however, more in accordance with all the phenomena of cohesion to suppose, instead of the attraction of the liquid being neutralized by the heat, that the effect of this agent is merely to neutralize the polarity of the molecules so as to give them perfect freedom of motion around every imaginable axis. The small amount of cohesion (52 grains to the square inch), exhibited in the foregoing experiment, is due, according to the theory of capillarity of Young and Poisson, to the tension of the exterior film of the surface of water drawn up by the elevation of the plate. This film gives way first, and the strain is thrown on an inner film, which, in turn, is ruptured; and so on until the plate is entirely separated; the whole effect being similar to tearing the water apart atom by atom.

"Reflecting on the subject, the author has thought that a more correct idea of the magnitude of the molecular attraction might be obtained by studying the tenacity of a more viscid liquid than water. For this purpose, he had recourse to soap water, and attempted to measure the tenacity of this liquid by means of weighing the quantity of water which adhered to a bubble of this substance just before it burst, and by determining the thickness of the film from an observation of the color it exhibited in comparison with Newton's scale of thin plates. Although experiments of this kind could only furnish approximate results, yet they showed that the molecular attraction of water for water, instead of being only about 52 grains to the square inch, is really several hundred pounds, and is probably equal to that of the attraction of ice for ice. The effect of dissolving the soap in the water, is not, as might at first appear, to increase the molecular attraction, but to diminish the mobility of the molecules, and thus render the liquid more viscid.

"According to the theory of Young and Poisson, many of the phenomena of liquid cohesion, and all those of capillarity, are due to a contractile force existing at the free surface of the liquid, and

which tends in all cases to urge the liquid in the direction of the radius of curvature towards the centre, with a force inversely as this radius. [The explanation of the existence of this contractile force will be given in the next section of the Notes, which considers Capillarity.]

"According to this theory, the spherical form of a dew-drop is not the effect of the attraction of each molecule of the water on every other, as in the action of gravitation in producing the globular form of the planets (since the attraction of cohesion only extends to an appreciable distance), but it is due to the contractile force which tends constantly to enclose the given quantity of water within the smallest surface, namely, that of a sphere. The author finds a contractile force similar to that assumed by this theory, in the surface of the soap-bubble; indeed, the bubble may be considered a drop of water with the internal liquid removed, and its place supplied by air. The spherical form in the two cases is produced by the operations of the same cause. The contractile force in the surface of the bubble is easily shown by blowing a large bubble on the end of a wide tube, say an inch in diameter; as soon as the mouth is removed, the bubble will be seen to diminish rapidly, and at the same time quite a forcible current of air will be blown through the tube against the face. This effect is not due to the ascent of the heated air from the lungs, with which the bubble was inflated, for the same effect is produced by inflating with cold air, and also when the bubble is held perpendicularly above the face, so that the current is downwards.

"Many experiments were made to determine the amount of this force, by blowing a bubble on the larger end of a glass tube in the form of a letter U, and partially filled with water; the contractile force of the bubble, transmitted through the enclosed air, forced down the water in the larger leg of the tube, and caused it to rise in the smaller. The difference of level observed by means of a microscope, gave the force in grains per square inch, derived from the known pressure of a given height of water. The thickness of the film of soap-water which formed the envelope of the bubble, was estimated as before, by the color exhibited just before bursting. The results of these experiments agree with those of weighing the bubble, in giving a great intensity to the molecular attraction of the liquid; equal at least to several hundred pounds to the square inch. Several other methods were employed to measure the

tenacity of the film, the general results of which were the same; the numerical details of these are reserved, however, until the experiments can be repeated with a more delicate balance.

"The comparative cohesion of pure water and soap-water was determined by the weight necessary to detach the same plate from each; and in all cases the pure water was found to exhibit nearly double the tenacity of the soap-water. The want of permanency in the bubble of pure water is therefore not due to feeble attraction, but to the perfect mobility of the molecules, which causes the equilibrium, as in the case of the arch, without friction of parts, to be destroyed by the slightest extraneous force."

The above investigation of Dr. Henry will be referred to again under the head of Capillarity.

Gases.—Between the molecules of the same gas repulsion exists, but a slight attraction appears to prevail between the molecules of different gases.

Adhesion.—*Of solids to solids.*—Plating of metals. Gold leaf stamped on metals. "It is known that if two pieces of metal are *scraped* very clean, a severe blow will make them to cohere so as to be inseparable. It is thus that flowers of gold and silver are fixed on steel and other metals. The steel is first scraped clean, and a thin bit of gold or silver is laid on it, and then the die is applied by a strong blow with a hammer. It is remarkable that they will not adhere with such firmness, if they adhere at all, when the surfaces have been polished in the usual way, with fine powders, &c. This is always done with the help of greasy matters. Some of this probably remains, and prevents that *specific* action that is necessary. I am disposed to think that the scraping of the surfaces also operates in another way, viz: by filling the surface with scratches, that is, ridges and furrows. These allow the air to escape as the pieces come together by the blow. If the mere blow were sufficient, a coin would adhere fast to the die. But, in coining, the flat face of the die first closes with the piece of metal, and effectually confines the air which fills the hollow that is to form the relief of the coin. This air must be compressed to a prodigious degree, and in this state, it is still between the die and the coin. We may say that the impression on the coin is really formed by this included air; for the metal in this part of the coin is never in contact with the die. I know of two cases, which greatly confirm this conjecture. The dies chanced to crack in the highest part of the relief, and after this were thrown aside (although in one, for a common die, the crack

was quite insignificant), because the coin could seldom be parted from them."—[*Robison.*]

When bladder is dried on glass, the adhesion is so great that it cannot be torn off without bringing with it some of the glass.

Of solids to liquids.—A rapidly issuing jet of water is deflected from its course by touching a glass rod.—Experiments quoted above, on relative cohesion.

Of liquids to liquids.—Oil and spirits of turpentine spread over the surface of water.

Of gases to solids.—Air and vapor of water adhere with considerable force to the surface of glass. This shown by placing a beaker of water under the receiver of an air pump, when bubbles of air, previously coating as a film the surface of the glass, collect on its surface. That vapor of water also coats with a film the glass, is known from the increase in weight of a dry light glass vessel, when exposed to a damp atmosphere.—The action of clean platinum and gold in condensing gases on their surfaces.—Charcoal absorbs 98 times its volume of ammonia, and 14 volumes of carbonic acid gas. As ammonia is condensed into a liquid by a pressure of seven atmospheres, at a temperature of 60° F., it follows that the absorbed gas must exist in the liquid state in the interstices of the charcoal. Gold leaf will not sink in water from the air condensed on its surface.

Of gases to liquids.—Air and all gas absorbed by water. Oxygen gas absorbed from the air by melted silver.

Of gases to gases.—In the diffusion of gases, one gas acts as a vacuum to another. Vapor diffuses in space containing a gas, until the same tension is produced as would have been acquired by the same vapor evaporating from its liquid in a vacuum.

Molecular Repulsion.

When the convex surface of a plano-convex lens, of a radius of curvature of 20 feet or more, is pressed upon a plate of glass, a system of concentric colored rings are observed. These rings are produced by the interference of certain of the rays of light reflected from the under surface of the lens with those reflected from the upper surface of the glass plate. By knowing the diameter of any ring, and the radius of curvature of the lens, we can calculate the distance between the convex surface and the glass plate corresponding to the ring. Newton thus found that the distance at each ring exceeded the distance of the ring immediately within it by the $\frac{1}{89000}$th of an inch.

Now, unless the lens be heavy, or pressed against the glass plate, no colored spot appears in the centre, and it can be shown that the glasses are, in this case, not in contact, but distant from each other at least $\frac{1}{4450}$th of an inch, and at this distance reposes the upper glass, kept from the plate by a *repulsion* existing between them.

By forcing the glasses nearer together, we at length produce a *black* spot at the centre of the ring system, and Prof. Robison found that "a very considerable force is necessary for producing the black spot. A greater pressure makes it broader, and in all probability this is partly by the mutual yielding of the glasses. I found that before a spot, whose surface is a square inch, can be produced, a force exceeding 1,000 pounds must be employed. When the experiment is made with thin glasses, they are often broken before any black spot is produced.

"What is it that we properly, and without any figure of speech, call a pressure? It is something that we are informed of solely by our sense of touch. What do we feel by means of this sense, when the upper lens lies in our hand? It is not the matter of this lens, for we now see that there is some measurable distance between the lens and the hand; it is this repulsion. Give a blind man a strong magnet in his hand, and let another person approach the north pole of a similar magnet to its north pole. The blind man will think that the other has pushed away the magnet he holds in his hand with something that is soft.

* * * * * * * *

"There is, therefore, an essential difference between *mathematical and physical contact;* between the absolute annihilation of distance and the actual pressure of adjoining bodies. We must grant that two pieces of glass are not in mathematical contact till they are exerting a mutual pressure not less than 1,000 pounds per inch. For we must not conclude that they are in contact till the black spot appears; and even then we dare not positively affirm it. My own decided opinion is, that the glasses not only are not in mathematical contact in the black spot, but the distance between them is vastly greater than the 89,000th part of an inch, the difference of the distances at two successive rings.

* * * * * * * *

"While gravity produces sensible effects at the utmost boundary of the solar system, these [attractions and repulsions] seem limited in their exertion to a small fraction of an inch, perhaps not exceed-

ing $\frac{1}{2000}$th part in any instance; and in this narrow bounds we observe great diversity in the intensity, although we have not yet been able to ascertain the law of variation. What is of peculiar moment, we have seen that those corpuscular forces even change their kind by a change of distance, producing at one distance, the mutual approach, and at another distance the mutual separation of the acting corpuscles, from being attractive, becoming repulsive.

* * * * * * * *

"Physical contact, or *pressure*, becomes *sensible* at the distance of the 5000th part of an inch nearly, and decreases much faster than in the inverse duplicate ratio of the distances. I could infer this from my experiments with the glasses with great confidence, although I could not assign the precise law." *Robison's Mechanical Philosophy*, Vol I. p. 250, *et seq.*

All bodies expand when relieved of pressure, and this expansion is caused by the mutual repulsion of their atoms.

A dew drop does not touch the leaf above which it reposes, but is held at a certain distance by repulsion. Certain insects walk on water, which is repelled by their feet, so that each foot rests in a pit. A needle floats on the surface of water, in which it forms a trough in which it rests.

Prof. Baden Powell has shown (*Phil. Trans.* 1834, p. 485), that the colored rings known as Newton's rings, change their breadth and position in such a manner, when the glasses which produce them are heated, that he inferred that the glasses repelled each other.

"The *distance* at which the repulsive power can act, is shown by these experiments to extend beyond that at which the most extreme visible order of Newton's tints is formed. But I have also repeated the experiment successfully with the colors formed under the base of a prism placed upon a lens of a very small convexity; and according to the analysis of these colors given by Sir John Herschel, the distance is here about the 1100th of an inch."

Very finely divided solids, such as elutriated silica and wood-ashes will, when rendered incandescent, flow like liquids about the capsule which contains them; while it can be directly shown that a sensible distance exists between a layer of these powders and a heated plate on which it rests.

(To be continued.)

A NEW FORM OF WAVE APPARATUS.

By Prof. C. S. Lyman.

[We find in a late number of *Silliman's Journal* a full description of the above, which is undoubtedly the most admirable piece of mechanism for the illustration of inter-molecular motions (such as those concerned in the propagation of waves), that has ever been devised. The beauty and admirable completeness as an illustration, of this apparatus, can only be appreciated by actual inspection of its operation. No description can convey an idea of the manner in which is revealed the complex, flexible, and yet regular motions of the interior particles of the fluid among themselves.—Ed.]

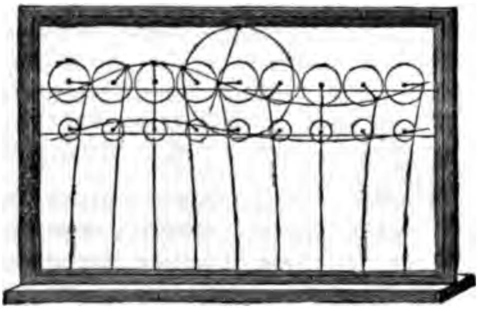
The theory of waves that has been generally taught since the days of Newton, is that which represents wave motion as consisting in the alternate rising and falling of the parts of a liquid in vertical lines, as in the two branches of a U-shaped tube; this is usually cited as Newton's theory of waves. There is to be found, indeed, in the *Principia*, the hypothesis of vertical oscillations, and also the cut of the bent tube, so persistently copied by subsequent writers; yet it is evident that Newton adopted the hypothesis, rather as an expedient for a special purpose—that of finding approximately the relation of a wave's length to its period—than as strictly true to nature; for he concludes his investigation with the remark:—"These things are true, upon the supposition that the parts of water ascend or descend in a right line; but, in truth, that ascent and descent is rather *performed in a circle* ('*verius fit per circulum*'); and therefore I propose the time defined by this proposition as only near the truth." This important qualifying clause seems to have been quite overlooked by those who have professed to give Newton's theory of waves.

The modern theory—which teaches that, in wave motion, all the particles of a liquid are revolving synchronously in vertical circles—though so broadly hinted at by Newton himself as the true one, in the words italicised above, has nevertheless been developed, for the most part, only within the present century. It was first clearly stated and ably advocated by Gerstner in 1804. More recently, it has been satisfactorily established as accordant with observed facts and the laws of Mechanics, by the experimental researches of Weber and Scott Russell, and the mathematical investigations of Stokes, Rankine, and others. A concise exposition and demonstration of the theory may be found in a paper by Prof. Rankine, in the Philosophical Transactions for 1863. Though but just beginning to find its way sparingly into the text books, it has become the generally accepted theory among men of science; and having in reality supplanted the old hypothesis as an expression of scientific truth, there

is no good reason why it should not also supplant it, in the lecture and recitation room.

In teaching this theory, however, it is often found difficult to make pupils understand, how the infinitude of simultaneous revolutions which it supposes can take place without mutual interference, and in such a way as to produce the observed phenomena. It was to obviate this difficulty, and illustrate, as far as practicable, the *modus operandi* in question, that the piece of mechanism was devised, which is the subject of this article. It presents to the eye not merely the surface contour of a wave, with its undulatory motion—which, to some extent, other forms of wave apparatus also do—but, besides doing this in a more exact and satisfactory manner, it exhibits the motions also that are at the same time taking place below the surface, in the whole mass of liquid affected. This completeness of illustration is due to the circumstance, that in the apparatus, the elementary motions are the same, essentially, as in actual waves; hence, the leading points, geometrical and dynamical, of the theory of waves, are presented naturally, and in their true relations.

The construction of the apparatus will be readily understood from a brief description, and the accompanying cut.



In front of a plane surface are two series of revolving arms or cranks, the length of the lower ones being half that of the upper. Two elastic wires connect the crank-pins of each series; upright wires also connect each pair of cranks, and pass down through a plate into the base. The cranks all revolve synchronously; they thus keep their relative position, and come into any given position successively, each in its turn. The relative position of the cranks of each horizontal series is such, that the directions of any two, in regular order, differ by the same fraction of a whole revolution, that the distance between their axes is of a whole wave length. Thus, in the apparatus, the wave length is supposed to be divided into eight equal parts, and hence the common difference between the directions of adjacent crank arms is one-eighth of a circle, as shown in the figure. The cranks in each vertical set have their

positions always alike. The number of cranks, whether taken horizontally or vertically, is arbitrary—a matter of convenience in construction. The synchronous revolution of the cranks is effected by means of any suitable mechanism; such as equal toothed wheels on the several axes, with alternate idle wheels connecting them; or, equal rag-wheels, with endless chain, or metallic ribbon; or, equal cranks, with a rigid connecting frame or plate. The first method is used in the original machine, the third in the model for the Patent Office, the second and third in the larger and smaller sizes, respectively, for the market.

The crank-pins represent as many liquid particles; the circles on the background their orbits. The transverse wires represent continuous lines of particles, which at rest would be horizontal, and be represented by the lines on the background drawn just below the centres of the orbits; the upper one of these being the surface line, the lower a line of particles one-ninth of a wave's length down. The upright wires represent lines of particles which at rest would be vertical. Every point in these moving lines describes its own distinct orbit.

The apparatus is constructed to a scale; and so, represents a wave of given length, height and period; but equally represents also, a wave of any other length and proportionate height, though of period proper to its length, according to the law of that relation, as stated farther on. In the original instrument, for example, the wave length it 36 inches; height, from trough to crest, 4 inches; and period, for that length, $0^{s}{\cdot}76$; but it equally represents a wave whose length is 36 feet and height 4 feet, with period $2^{s}{\cdot}63$; and similarly, for other proportional dimensions.

Among the particular points, in wave phenomena, which are elucidated by this apparatus, may be enumerated the following:

1. *The undulating surface-profile.* This is shown in the motion of the upper flexible wire, which presents a continuous contour line, of the exact curvature, throughout, of a true normal wave; instead of a broken contour, of arbitrary form, by means of rising and falling balls, as in the ordinary wave apparatus.

2. *The undulatory motion of all sub-profiles, or lines of equal pressure, down to still water.* The representative of such lines is the lower transverse wire, which moves similarly to the upper one, but with a less curvature. Every such line of equal pressure is a continuous one, composed of particles in a state of dynamical equilibrium, and constituting an ideal moving wave, exactly as if at the surface —the corresponding phases of all such waves being on vertical lines.

3. *The genesis of the undulatory motion from the circular motion of revolution.* This is seen in the mode in which the crank-pins, in each transverse series, or the particles which they represent, come in regular succession into a given position, as they revolve synchronously in their orbits.

4. *The equality of the height of a wave, from trough to crest, with the diameter of the orbits of the surface particles.* This is obvious in the apparatus, and follows directly from the mode in which the wave surface is generated.

5. *The direction of motion of particles of water in the different phases of a wave.* A glance at the motion of the crank-pins, shows that a particle at the wave's crest is moving forward, or in the direction in which the wave is propagated, and a particle at the trough in the reverse direction, or backward; that a particle on the forward slope is rising, and one on the back slope descending. The same is true of particles in all the sub-waves, or surfaces of equal pressure, down to still water.

6. *The length of a pendulum keeping time with the wave.* This is equal to the radius of a circle whose circumference is the wave's length. Such a circle is the large one drawn on the back-ground, as shown in the figure. Its radius is to that of a particle's orbit (or length of a crank-arm), as the particle's weight is to its centrifugal force. Or, putting R and r for these radii respectively, and t for the time of revolution, we make

$$R : r :: g : \frac{4\pi^2 r}{t^2};$$

Whence

$$t = 2\pi\sqrt{\frac{R}{g}};$$

which is the period of a revolving pendulum, or the time of a double oscillation of a simple pendulum, whose height is R. Compare (10).

7. *The dependence of a wave's period on its length alone—not on its height.* This is a corollary from the preceding. The period varies as the square root of the length, and is the same for all sub-waves, as for the surface-wave—the length being the same for all. The height, within certain limits, is independent of the length, as appears in the apparatus, and as may be inferred from the formulæ given farther on. It depends on the centrifugal force of the particle, and this, ultimately, on the external forces generating it.

8. *The varying direction and intensity of the resultant force acting at each instant on a given particle in a wave.* The component forces are two—the particle's gravity, and its centrifugal force. The former is represented by the vertical radius of the large circle, the latter by the radius vector of the revolving particle; their resultant, then, is represented by the third side of the triangle of forces, or the side formed by the wire pendulum. This resultant must be always normal to the wave surface, as the wire pendulum is seen to be always at right angles to the elastic wire representing that surface.

9. *The condition of a wave's rupture at the crest.* When the centrifugal force becomes equal to gravity (or the radius of the orbit to that of the large circle), the resultant force, for a particle at the highest point of its orbit, or crest of the wave, must be zero, and

the particle consequently fly from its orbit, or the crest break in foam.

10. *The trochoidal form of the wave curve.* The point of suspension of the pendulum, that is, the upper extremity of the vertical radius of the large circle, may be regarded as the instantaneous centre about which an element of the wave curve at the point of normalcy of the pendulum is described. Consequently, if this circle be rolled under a horizontal straight line, a point within it distant half the weight of a wave from the centre, will trace the wave profile; which, therefore, is a trochoid. The rolling circle is the same for all wave profiles, down to still water, the lengths of the tracing arm only differing. The circumference of this circle equals, of course, the wave's length.

11. *The greater sharpness of the crests than of the troughs of waves.* This follows from the preceding, and is shown in the relative positions of the crank-pins—nearer together at the crests, farther apart in the troughs. The trochoids become, necessarily, sharper at the upper bend, and less so at the lower, as the tracing arm approaches to an equality with the radius of the rolling circle; until, when that equality occurs, the trochoid passes into the cycloid, which has sharp cusps. The cusp of the inverted cycloid, then, is the limit of sharpness of a wave's crest. The quality above named is equivalent to that of the centrifugal force of a particle with its gravity (9). When the latter condition occurs, the wave curve is cycloidal, and only then.

12. *The limits of possible curvature of waves.* That curvature must always lie between the cycloid at the one extreme, and the straight line at the other—embracing trochoids of every possible variety.

13. *The greater elevation of the crests above the level of still water, than depression of the troughs below it.* The difference between this elevation and depression is equal to twice the height due to the orbital velocity of the particles, that is, to twice the height from which a body must fall to acquire that velocity; or, is a third proportional to the radius of the rolling circle and that of the particle's orbit; that is, putting R and r for these radii respectively, v for the orbital velocity, $\left(=\frac{2\pi r}{t}\right)$, and D for the difference in question,

$$D=\frac{r^2}{R}=\frac{v^2}{g}.$$

When r equals R, then $D=r$, or half the height of the wave.

14. *The elevation of the centres of the orbits of particles above the positions of the same particles at rest.* This is shown in the distance of the axes above the corresponding lines on the background. These lines show the positions of lines of particles at rest, which, in motion, form the wave profiles represented by the transverse wires.

The elevation in question is equal to the height due to the particle's orbital velocity; or, is a third proportional to the diameter of the rolling circle and the radius of the orbit; or, is equal to the area of the orbit divided by the length of the wave; that is, putting H for this elevation, l for the wave's length, and the other symbols as before,

$$H=\frac{r^2}{2R}=\frac{v^2}{2g}=\frac{\pi r^2}{l}.$$

When r equals R, $H=\frac{r}{2}$, or one-fourth the height of the wave.

To this elevation is due one-half the mechanical energy of a wave —the other half to the motion of its particles. That energy is, in other words, half potential, half actual.

15. *The decreasing diameter of the orbits with depth.* This is seen in the shorter crank-arms below, and the decreasing amplitude of sway of the upright elastic wires, down to their points of rest, which mark the depth of still water. The decrease of the orbits in diameter takes place in a geometrical ratio, and is approximately one-half for each increase of depth equal to one-ninth of a wave-length; or, more exactly, putting r and r' for the radii, respectively, of a surface orbit and of one whose middle depth is k, it is $r_{,}=re^{-\frac{k}{R}}$, R being, as before, the radius of the rolling circle, and e the base of the Naperian logarithms.

16. *The peculiar swaying motion of continuous lines of particles of equal pressure, which at rest are vertical.* These lines are alternately lengthened and shortened, and bent to right and left, as represented by the upright elastic wires.

17. *The varying distortions undergone by blocks or sections of water originally rectangular, or rectangular when at rest.* Such sections are represented by the spaces between the wires, and their distortions by the distortions of these spaces.

18. *The fact of sensibly still water at half a wave's length below the surface.* This is exhibited in the absence of lateral motion at the lower extremities of the upright wires, and is a necessary result of the law of diminution of orbits with depth, as given above (13).

19. *The varying strain, in wave action, on floating bodies.* This is seen in the varying angle made by the upright wires with the upper transverse wire; the latter shows the position of a raft, for example, lying on the wave surface; the former, that of a long, thin body, as a board, floating end down; hence, the varying relative direction of the wires shows the strain to which a body is subjected, having both breadth and depth, as the hull of a vessel.

Many other points besides the above, may be studied to advantage in connection with this apparatus, but it is not important to specify them here. Enough have been stated to illustrate its utility,

and indicate in what respects it differs from every other form of wave apparatus.

For convenience of reference, and for the sake of completeness, a few formulæ are added, expressing other relations among wave phenomena, not so directly exhibited by the instrument, but important to be presented in connection with it. Putting V for the velocity of propagation of a wave, and the other symbols as before, the length of the wave is

$$l = 2\pi R = \frac{gt^2}{2\pi} = \frac{2\pi V^2}{g} = tV;$$

its period
$$t = \sqrt{\frac{2\pi l}{g}} = 2\pi\sqrt{\frac{R}{g}} = \frac{l}{V};$$

the velocity of a particle in its orbit; or at the crest of the wave,

$$v = \frac{2\pi r}{t} = r\sqrt{\frac{g}{R}} = r\sqrt{\frac{2\pi g}{l}} = \frac{Vr}{R} = \frac{2\pi r V}{l} = \frac{gr}{V} = \frac{tgr}{l};$$

the velocity of propagation of the wave

$$V = \frac{l}{t} = \frac{gt}{2\pi} = \sqrt{\frac{gl}{2\pi}} = \sqrt{gR} = \frac{gr}{v}.$$

the sine of the angle of steepest slope of surface is

$$\sin\theta = \frac{2\pi r}{l} = \frac{r}{R};$$

It will be understood that the normal wave, to which the theory applies, and which the apparatus illustrates, is the wave on deep water, or water a wave's length, at least, in depth. In shallow water, the orbits are no longer circles, but ovals, or approximate ellipses, of less height than length, according to the degree of shallowness.

When waves pass from deep into shallow water, as toward a beach, they become gradually shorter, their total energy is imparted to a less and less mass of liquid, and the extent of the motion of the particles is proportionately increased. The crests also travel faster than the troughs; so that the front of each wave becomes by degrees steeper than the back, and at length curls forward and falls over, exhibiting the well known roll of surf. The formulæ for waves in deep water require modification, therefore, to adapt them to waves in shallow water, where depth of liquid and ellipticity ot orbit enter as elements.

It has been necessary, in order properly to explain the apparatus and its uses, to give more fully the leading points of the theory of waves, than would be required, were the works containing it more generally accessible. For these points the papers of Prof.

Rankine have been chiefly consulted. It is hoped that this outline of the theory, thus incidentally given, will prove not unacceptable to such instructors as may not have at hand the original works; and that this new piece of apparatus may contribute somewhat toward imparting a clearer understanding of the phenomena of waves.

The apparatus has been patented, and is manufactured by Messrs. E. S. Ritchie & Son, the well known philosophical instrument makers, of Boston, Mass.

THE GIFFARD INJECTOR.

(Concluded from page 130.)

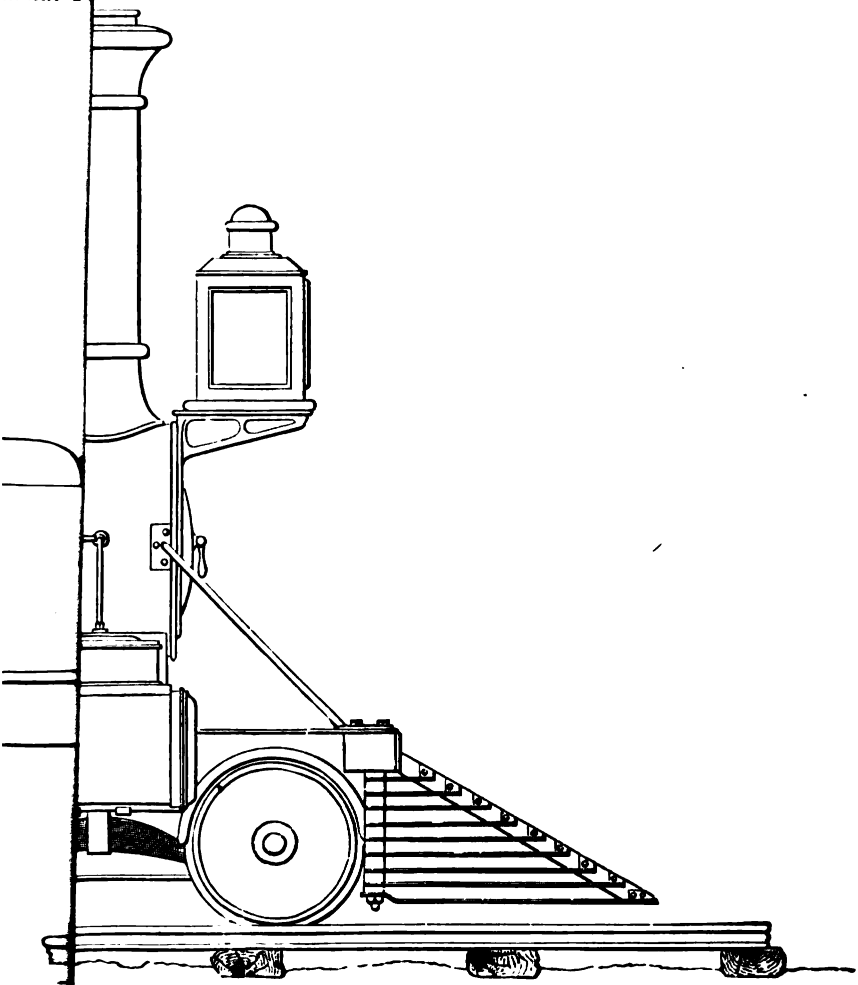
We will now consider in the first place, the attachments needed when the injector is used upon a locomotive. The general arrangement of the instrument and its accessories will be readily understood from the accompanying Plate I., in which A represents the starting valve, B, the check-valve to the water supply, C, the regulating handle, D, the delivery pipe to the check-valve on the boiler, E, the escape or waste valve, F, the waste pipe, G, the alarm check and pipe to drip-pan, which is on the end of the boiler immediately in front of the engine-driver.

Among these attachments we will first select for description, the starting valve.

It will be readily perceived, from what has been already explained, that for the certain and successful operation of this injector, it should at first have a small supply of steam, in order to bring the water up into the nozzle, C, Fig. 4, and when this is accomplished, then a full supply, capable of carrying water into the boiler.

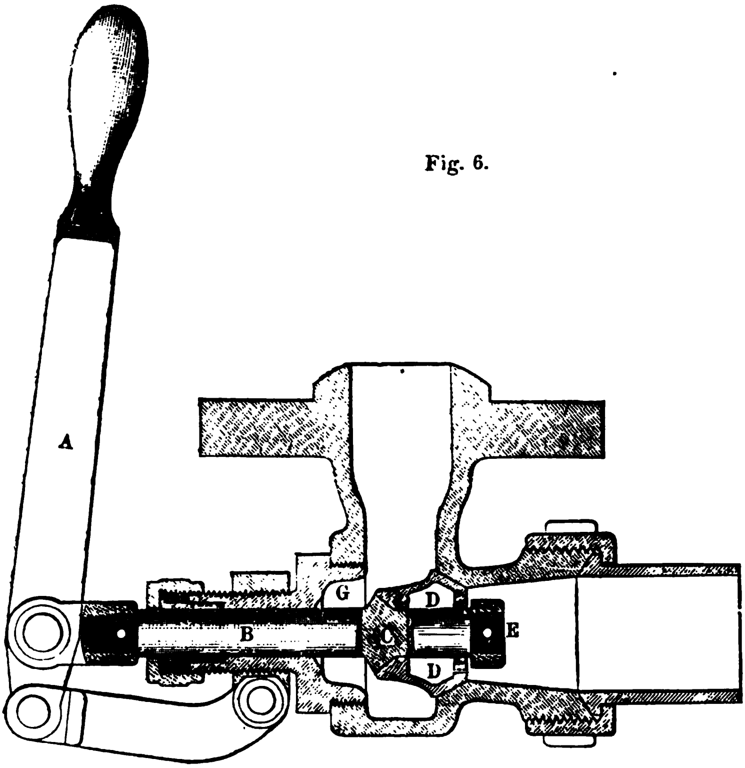
Even with the provisions of the interior passage in the plug, already described, with the high pressure often carried on locomotives, if the full head of steam was let on to the injector at first, it would prove too much for the outlet of C, while if the tube in the plug were made small enough to prevent this, it would then be too small to work with the low pressures which it is necessary sometimes to use. To meet this difficulty the starting valve, shown in Fig. 6, is used. In this case we have a double valve; that is, the stem C, fits by a conical face upon the valve, proper, D D; but when drawn back as far as the nut, E, will allow, steam can pass through the body of the large valve, by the small opening indicated in the drawing, and into the pipe E.

urnal F



It is found, in fact, very important that this opening should be very small, for it would otherwise be impossible to admit a sufficiently small amount of steam when a high presssure exists in the boiler. This can be well understood if we consider that under a pressure of say 90 lbs. to the square inch, the volume of the steam is reduced to one-sixth, and that thus a small orifice can deliver a quantity which will have a great volume when subsequently ex-

Fig. 6.



panded under an atmospheric pressure only. It might, perhaps, be supposed that a conical valve, like that shown at Fig. 4, operated by a fine threaded screw, would accomplish the same end. This is true as regards the gradual admission of steam at starting, but then, the time required to open the valve so as to give a full head of steam when required, would be excessive, and would occasion in practice great inconvenience. To open any ordinary valve, capable of admitting the maximum flow which would be required on some

occasions, with sufficient delicacy to start the injector with a high pressure of steam, would be impracticable, especially under the existing conditions of jar and motion in a locomotive.

The effect of this arrangement will be evident when we describe its operation.

Steam from the boiler filling the space, G, and pressing upon the valve, D D, keeps it firmly in its seat, so that when the handle, A, is pulled out with moderate force, the stem, B C, is alone moved, until the nut, E, is arrested against the face of the valve. The resistance offered by this valve will be very sensibly perceived, and will indicate when sufficient motion has been given to the handle.

Through the opening thus exposed by the interior valve, C, steam passes into the pipe, E, and to the injector, not only with sufficient rapidity to raise water for the action of that instrument but also in such quantity as to accumulate in the pipe, E, so as to balance, in part, the pressure on the valve, D D, and thus render it easy when the right time comes (which is after a few moments) to open this valve by a further motion of the handle, A, and admit a full head of steam to the injector.

Thus the necessities of the case are provided for in this respect.

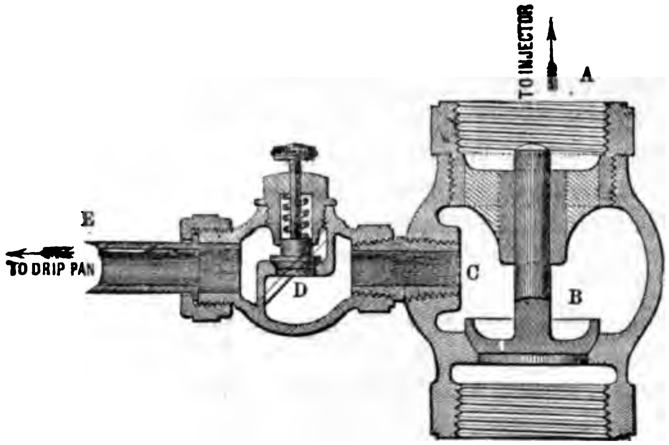
It is again of vital importance that the engineer should be notified whenever the injector, from any cause, either ceases to operate or fails to start. This is secured by means of the *alarm check valve*, which we will now describe.

If the injector is not working into the boiler when the escape valve, (P. Fig. 4,) is closed, it is clear that the steam will back up in C, and tend to pass out into the water supply and tank. As soon, however, as any pressure occurs in the upper part of the supply-pipe, the check-valve, B, Fig. 7, will close, and the steam then exerts its pressure on the small check, D, in the lateral pipe, C E, which leads to the drip pan. This small valve, which is kept in its seat by a spiral spring, as shown in the drawing, will then be raised, and allow the steam to escape into the drip pan in a way that cannot fail to secure notice.

In cold weather it is important to have some means of passing steam into the tank to avoid freezing. To accomplish this, a small opening is made through the valve, B, Fig. 7, as shown in the drawing, which allows steam enough to pass for the above purpose, when there is no other outlet, but is not sufficiently large to interfere with the working of the valve in other respects

The escape valve, P, Fig. 4, being closed and steam let on, no jet can be established nor any water forced into the boiler, the pressure of steam will then be exerted to force its way into the water supply and lateral pipe. A stop valve or cock being placed at some convenient position on the latter, and closed, the steam will pass only into the tank by the opening in the water check valve.

Fig. 7.



It must, of course, be remembered, that after driving steam through in this way for some time, the feed pipe and its contents will become highly heated. It will, therefore, be impossible to start the injector until this very hot water has been drawn through and ejected by the escape valve.

If this precaution is neglected and the full head of steam is given to the injector before the hot water has all been expelled by the light jet, then, there being no condensation in the nozzle, C, Fig. 4, (or an insufficient one) the jet will not be driven into the boiler, but will back up into the supply pipe, and will drive hot water and steam through the supply pipe to the tank, thus re-establishing the conditions securing failure; so that if another attempt is made at once to start the apparatus, it will fail, exactly as before, and so on perpetually, until the water in the supply pipe is no longer hot; an end to be reached in practice, of course, not by waiting until it cools, but by blowing it out, as before directed.

We come, lastly, in connection with these locomotive attachments, to the main check valve. The object of this evidently is to pre-

vent the water of the boiler from running out through the injector, should anything go wrong.

It is, moreover, so constructed that it not only acts as an automatic check-valve, but it is also arranged so that if, by chance, it sticks up and fails to close, it may be forced down into its seat, and turned round so as to remove obstructions. (See Plate II., main check.)

To accomplish these objects the upper part of the valve is provided with parallel plates cast with it, forming, in fact, a rectangular slot in which fits freely a plate suspended from the T slide of the valve stem which ends above in a button. By this means the valve easily rises and falls, being guided by the part of the stem below the valve, but if it should stick up, it may be at once forced into its seat by pressing on the button, or turned round upon its seat so as to grind out any foreign substance without cramping its guiding stem.

This concludes the category of attachments required for locomotives, their connected arrangement and details being shown in Plate II.

In connection with stationary engines, the only attachments required are the alarm check, main check, and, when there is pressure in the water supply, a water regulator in connection with the water check valve.

This arrangement is shown in plate III. Here we have a sort of balance valve in which the water from the supply, presses upon the inner face of the valve, and also upon the small piston on the same stem, whose outer surface opens to the air through the case. These surfaces are so adjusted that the valve would remain closed by reason of the water pressure, but if a partial vacuum is produced in the pipe, D, by the action of the injector, then the valve will be opened by this force, the amount of its opening being controlled by the position of the stem which is detached from it.

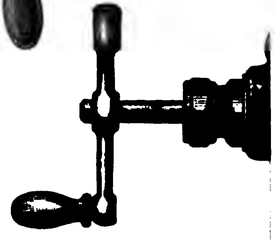
Of course any pressure in the pipe, D, will at once close this valve, so that it acts also as a check valve, which would cause the steam to pass through the alarm check into the waste pipe, so as to attract notice.

With regard to the economy of the Injector, we may look at the subject in a purely theoretical point of view, and reach a conclusion founded upon general principles which we will find to be sustained by the rough, and yet in its aggregate result, still more valuable test, of practical experience.

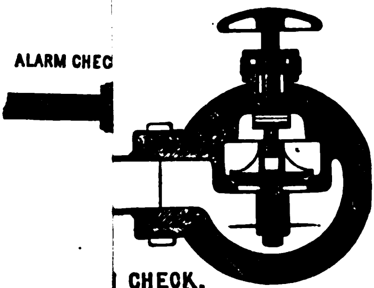
From what we have already seen in reference to the mode in

Journal Franklin Institute, ~~|~~*jector.* ***Plate II.***

STARTING VALVE.



ALARM CHEC



CHECK.

which the Injector acts, it appears that the entire force which passes from the boiler in the issuing steam, is returned to it, with the exception of that expended in lifting and injecting the feed-water, and so much as is lost by radiation of heat from the various parts and connections. This is, of course, when all is in proper adjustment.

The steam which escapes, is returned in a condensed form, and the loss of velocity with which it re-enters, represents the force required to raise and introduce the added quantity of water which it carries in with it against the resisting pressure of the boiler. Were any force expended otherwise, it must show itself either as visible motion or as heat. But there is no motion, and indeed, there are no moving parts, and any heat developed in the instrument would be carried into the boiler by the jet, and thus not be lost. We thus see that as a means of introducing water into a boiler, without regard to any accidental modifying conditions, this instrument must be economical, as it only expends the force needed to accomplish the work; whilst in all forms of pumping apparatus a loss of power is occasioned by the friction of various parts, and by their intermitting motion requiring a column of water at rest, and the reciprocating parts of the machine itself to be put in motion at every stroke.

If, however, in some particular case, the comparison is made between the Injector using relatively cold water, and some other means of feeding, combined with apparatus for heating the feed-water by waste heat, the Injector loses its absolute theoretical advantage, to a certain degree. It then depends for its title to superiority upon its convenience and simplicity of structure, which relieve it from expensive repairs and from the risk of derangement and consequent stoppages of works, to which the wear and tear of various moving parts, with their peculiar reciprocating action upon an incompressible material, renders pumps especially liable.

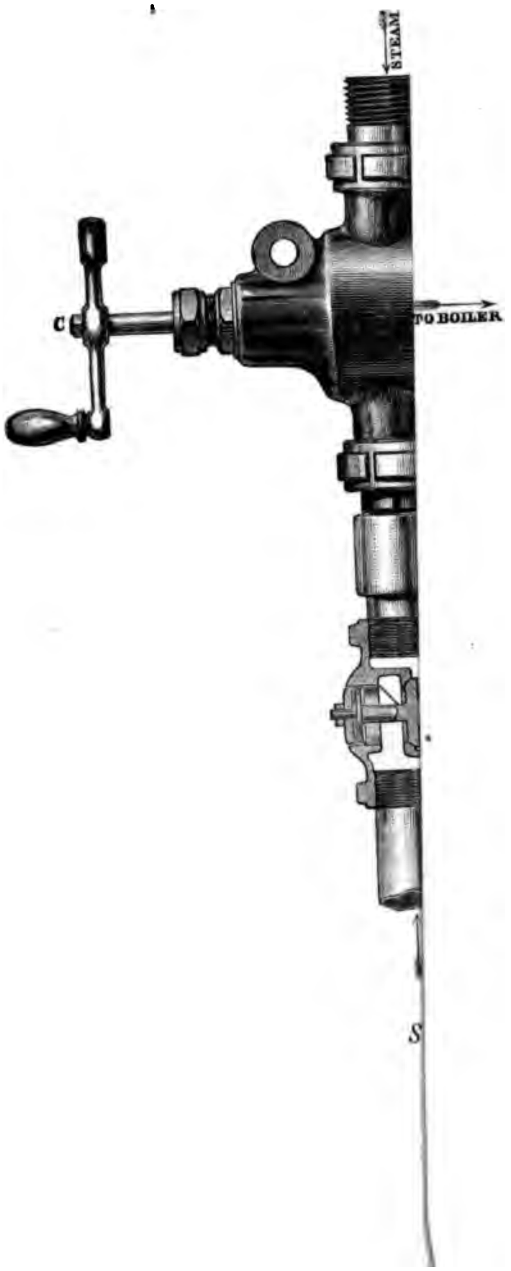
That the loss of absolute theoretical advantage in the Injector, compared with a combined pumping and heating apparatus is *in fact*, slight, will be evident when we remember that with the Injector, as with other means of feeding, waste heat may be employed to act upon the water between the feeding apparatus and the boiler, the difference being simply this: that with a pump, for example, the water will pass into this heating apparatus at its natural temperature and will get *all* the heat it acquires before entering the boiler

from the waste heat, while in the case of the Injector, the water in passing through that instrument, will acquire a certain amount of increase in temperature at the expense of the steam from the boiler before it comes in contact with the waste heat. This fraction, then, of the supply which might otherwise be derived from waste heat, is all that is sacrificed by the Injector.

We therefore conclude, that in all cases in which the feed-water is not heated by using heat otherwise wasted, the Giffard Injector is, to use the words of an eminent French writer, M. Ch. Combes, Inspector-General and Director of the *Ecole des Mines*, "Without doubt, the best of all those hitherto used for feeding boilers, and the best that can be employed, as it is also the most ingenious and simple," * * * * "and is theoretically perfect;" and that even when the comparison is made under the conditions least favorable to itself, this instrument still maintains a practical superiority.

THE MECHANICS OF SPIRITUALISM.—Dr. Peper, of the Polytechnic Institution in London, so well known for his ingenious inventions of the ghost, the floating head, &c., has for some time past employed himself in the development and exhibition at the above named institute of sundry contrivances, by which all the wonders of spiritual manifestations have been not only paralleled but exceeded. One of the most remarkable of these consisted of an arrangement by which various objects and persons were caused to rise in the air and remain there suspended under conditions which implied the impossibility of any supporting wire or thread however fine and invisible.

When, however, we mention that in the patent by which these contrivances are secured to their inventors' use a large plate of glass figures as the "invisible means of support" of these light characters, the wonder of the thing will be somewhat diminished, while the simplicity and ingenuity of the idea may well claim praise. In a foreign scientific journal we see some tricks of the Davenport Brothers, are described and are declared inexplicable, and yet we have repeatedly seen performances, involving every important feature of these *super-human* developments, made by an amateur in the arts of legerdemain in the presence of many spectators, and defying all their ingenuity of detection. Yet to those initiated, these feats are as easily reduced to the domain of nature and mechanics as Dr. Peper's wonders when the glass is recognised.


STEAM
C
TO BOILER
S

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

BY PROF. HENRY MORTON, PH.D.

(Continued from page 186.)

ANOTHER remarkable feature of the lunar structure is, the enormous size of many of its circular mountains or volcanic craters. Thus the largest of these distinct and clearly-defined circles, excluding all the vast wall-surrounded plains, of which we have before spoken, and which are many times larger, is Clavius, near the south pole, whose diameter is 132 miles. We are all familiar with similar distances as traversed by the locomotive and train; but what an idea it gives of the grand extent of the objects we view in the moon, to think of them in such connection. Take, for example, the road from this place to New York, which most of you, no doubt, have traversed. Think how, hour after hour, with the rush of the train, you sweep over meadows and woods—through fields, villages and towns—across land and water. The Delaware, the Raritan, the Passaic—not to mention, perhaps, the Schuylkill, and the Hudson at either end, are crossed—five great rivers, the least of which would float the navies of the world, with all the intervening land and its populous cities, and then, at the end of four hours thus spent, you have traveled a distance which is less by thirty-five miles than the diameter of Clavius, so that we must reach back into another state, and add, say, the distance from Philadelphia to Newcastle, in Delaware, to the other journey, to equal the space we should traverse, could we in like manner glide across that little circle, that barren plain called Clavius, walled in by its rim of precipitous rocks, rising abruptly no less than three miles high, often, in a vertical precipice.

So, again, we have Schiller and Schicard, each about 120 miles in diameter, and Maginus (4) 80 miles; Longomontanus (5) 70 miles; Maurolycus (15) 81 miles; Walter (17) 80 miles; Arzachel

(25) 70 miles; Alphons (30) 91 miles; Albategnius (50) nearly 80 miles; Ptolemaus (31) 80 miles, and a great number of others of like dimensions; while referring to some more familiar objects, we find Tycho, Copernicus, Archimedes (41), and Plato, all from 40 to 50 miles in diameter.*

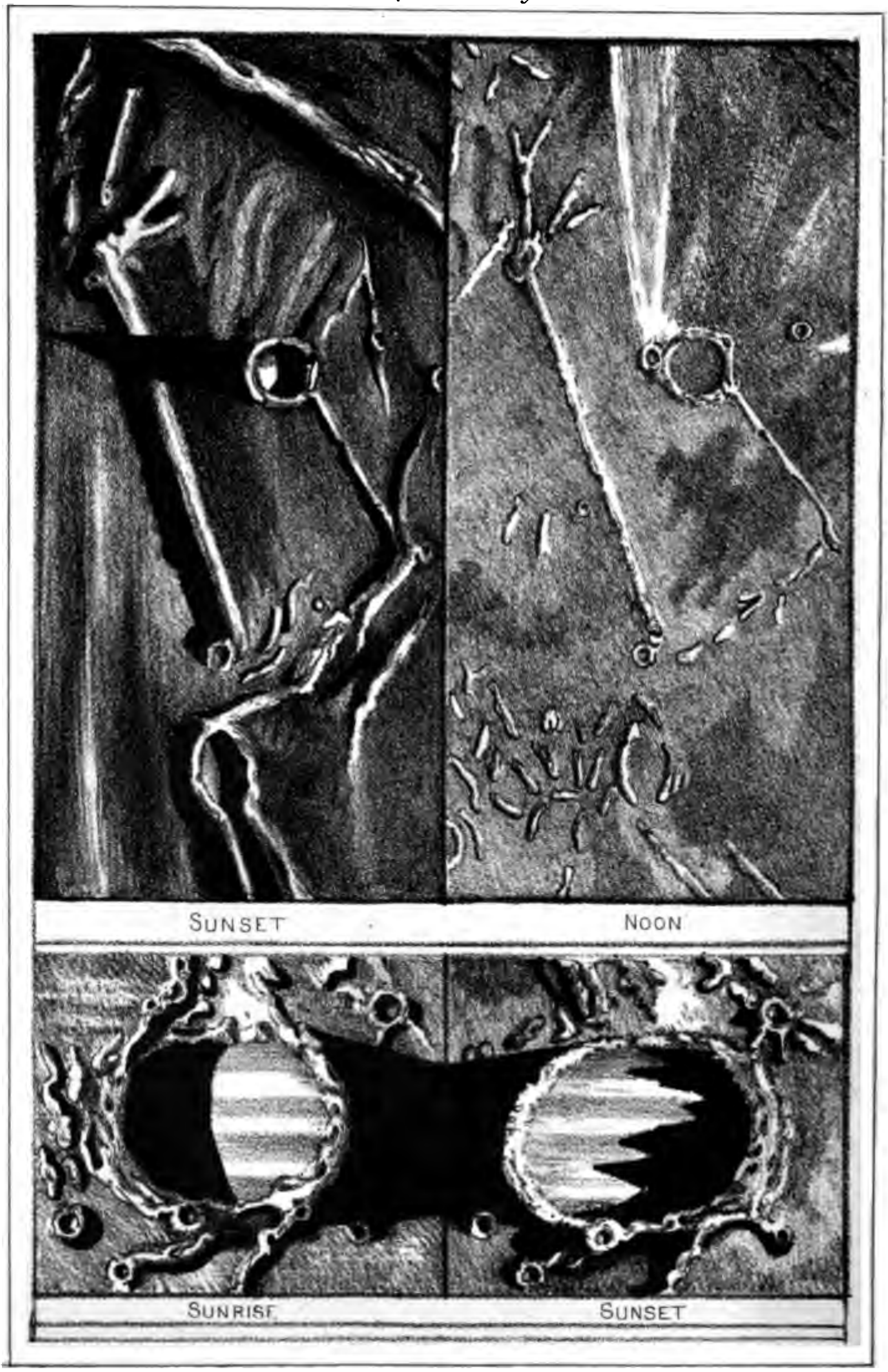
The cause of this stupendous size in the lunar craters is not difficult to find, and seems, evidently, to lie in the three following conditions. If, as is natural, we suppose the moon to have been at first in a fluid state, and to have cooled by exterior radiation, the rapidity with which that chilling would have been effected would be very great, both on account of the large proportion of the surface to the mass, as compared with the earth for example, and because of the absence of an atmosphere, which, as Tyndall has shown, is of immense importance as a means of arresting the escape of heat. This would have made the volcanic actions (supposing these to result from the cooling and contraction of the outer shell upon the fluid nucleus,) very violent. Then, in consequence of the less mass of our satelite, gravitation on her surface would be but one-fifth as great as on the earth, by reason of which, matter projected from a volcanic outlet, would have been driven to a great distance; and, lastly, the absence of an atmosphere, relieving all projectiles of atmospheric resistance would greatly extend their range of flight, and thus cause them to be deposited at a great distance from the centre or vent.†

Many of the same causes which are concerned in the enormous lateral magnitude of the lunar volcanoes, are likewise involved in the development of their relatively vast and precipitous height.

The greatest height attained by a lunar mountain, is that exhibited by Newton, whose peak only is shown in our map, Plate II., lit by the sun (rising on that portion of the planet,) under the letter h, of the word "south." Its height is about 4½ miles. This is an actual elevation less than that of many terrestrial mountains above the level of the sea; but when we compare the relative sizes of the globes on which these peaks occur, we see that their diameters

* The numbers in brackets refer to the locations similarly marked on Plate II.

† The effect of atmospheric resistance on the flight of projectiles, may be well illustrated by the following example which Dr. Young adduces. A musket-ball, with an initial velocity of 1670 feet per second, would have an horizontal range of about five miles in vacuo, but, in fact, reaches but one mile in the air.—Young's Natural Philosophy, Vol. I., p. 80.


SUNSET
NOON
SUNRISE
SUNSET

being as 4 to 1, our terrestrial mountains should be 18 miles in height, to equal those of the moon.

It is true, that we do our own peaks an injustice, by measuring them from the surface of the ocean, while with the moon, there being no water, and so no ocean surface, we measure from the very abyses of its unfilled valleys; but even then we should have only a height of 10 miles on the earth to match with an equivalent one of 18 miles from the moon.

You might naturally inquire, in this connection, how it is that we can measure so precisely the height of lunar mountains. I answer, simply by measuring the length of the shadows they cast in known positions of the sun. From the perfect blackness and sharply-defined terminations of the lunar shadows, this measurement is not difficult, and enables us, beside, to note with great certainty the actual profile and true topographical conditions of the lunar surface, where otherwise we might be deceived by the effects of that difference in reflecting power, to which we have before alluded.

These facts and conditions are well illustrated in Plate III. The two upper drawings are taken from Liais' beautiful work, entitled "l'Espare Céleste et la Nature Tropicale," and represent the same location (a range of hills and volcanic cones in the Mare Nubium) as seen near sunset, and near noon of the lunar day.

It will be there seen how the shadows of sunset bring out the inequalities of level and obliterate the various markings not produced by such a cause, but resulting simply from unequal reflecting power. This is specially notable in the right-hand upper corner of the sunset view: a range of hills appears clearly marked, which was imperceptible in the noon picture; while on the other hand the rays which at noon show clearly from the volcanic ring, are all gone in the evening.

The lower pictures on the plate are from an admirable little book by Guillemin, entitled "La Lune," and represent a volcanic crater as seen at sunrise and sunset.

We there see from the shadow projected on the interior plain, that the right hand or western edge consists of a series of precipitous peaks, while the eastern one is a level rampart. (These drawings, like Plate II., show the objects as seen in the telescope, therefore, inverted, as compared with their actual positions.)

(To be continued.)

LECTURES ON VENTILATION.

By Lewis W. Leeds.

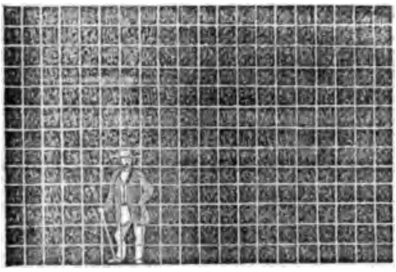
Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 141.)

The beating of the pulse is the action of the heart in pumping the blood from the extremes of the body, and driving it through the lungs to be aerated. There are, on an average, about seventy-two pulsations of the heart every minute, and two ounces of blood are passed through the lungs at each pulsation, or from sixty-five to seventy gallons every hour, and from forty to sixty barrels per day. I designed by this piece of red flannel (see cut, Fig. 3) to represent the number of cubic feet of blood passed through the lungs every twenty-four hours.

We thus see the very large amounts of blood and air that circulate through the lungs, and can easily imagine of how much greater importance the proper supply of air is to the maintenance of good health than the supply of food, because, while we eat less than two pounds daily, we breathe fifteen times that amount, or about thirty pounds.

Figure 3.



The amounts here given are only approximations, they are subject to extreme variations.

We all know the wonderful effect of any violent exercise, how it sets the heart to beating, or, in other words, the blood to circulating, this at once requires more air; we begin to breathe faster and inhale and exhale much larger quantities.

It is astonishing how many persons disregard this wonderful provision of nature for keeping off diseases, or for curing it after we have, by our own negligence, allowed it to affect our bodies.

The simple difference in the amount of blood and air which circulate through our systems, under different circumstances, shows us what control we have over our bodies in this respect.

The variation in this circulation from entire repose to vigorous action, may be thirty or forty per cent.—say thirty per cent.—taking the average amount of air breathed at three hundred and sixty-three feet, thirty per cent. of this would be near one hundred cubic feet difference in the amount of the air breathed; and taking fifty barrels as the average amount of blood circulated through the body, thirty per cent. would be fifteen barrels.—Fifteen barrels of blood! coming to the lungs to be purified, to be aerated, and one hundred cubic feet of air, an amount thirty or forty times the bulk of the body, and this the *difference* only, not the actual amount, but just the difference between a state of perfect quiet and that of active exercise.

What a means this is of influencing the condition of the body, and what an incentive to active exertion instead of sluggish, stagnant quiet.

Every child going to school ought to walk two miles in going to school and two miles in the evening in returning home; and no children ought to see the inside of a school-house, until they were quite able to walk that distance in all kinds of weather, without any inconvenience. This positive *necessity* for daily exercise is an advantage, as when it can be avoided it is frequently omitted in stormy and unpleasant weather, much to the injury of the child's health.

It is quite a common idea with many persons, that if they feel unwell in the spring of the year, that their blood must be out of order, it is impure. Now there is but little doubt but the blood of too many persons is very impure, but how do they attempt to purify it? Why by taking some vile compound in the shape of some patent pills, or other miserable stuff.

What would you do with a servant that would neglect to put coal on the fire, and just when she was in a hurry to get breakfast or dinner, finding the fire was nearly out, to make amends for her negligence, should pour turpentine or kerosine on, making a great smoke and a temporary blaze? and probably, if a little careless in its use, would set the chimney on fire, and run much risk of burning the house down.

Well, now, it is just as reprehensible for you to go on all winter neglecting to supply yourself with pure air, and in the spring find yourself weak, debilitated with impure blood, and your fire nearly out, and then to make amends for your carelessness, take some de-

testable pills or some of the world-renowned humbugs in the shape of patent tonics, that, according to the advertisement, are a certain cure for all diseases to which "human flesh is heir." And you might suppose from the reading of these advertisements, that they were an entire and perfect substitute for pure air.

I believe I never was quite so foolish as to take a bottle of any such stuff; but I think there must be a great many who do, from the splendid palaces that are constantly being built from the profits on the sales of such trash.

You might, at first, suppose that physicians, and almost every one else, would have learned by this time the best cure for consumption; yet how generally you find persons with this disease shut up in close rooms, breathing very impure air, and taking extra pains not to allow any *draughts* of any kind to enter the rooms.

I say, you would scarcely suppose it possible that such a contrary course would be pursued; but we must remember how short a time it has been since physicians would not allow the patient to follow the dictates of nature, and drink cold water in fevers.

And most of us remember how common it was, but a few short years ago, to take the very life-blood from a sick person, just at a time when it was most needed in carrying off the disease from the system.

It is not in consumption alone, that fresh air is of such great importance, but it is in all the diseases of the human body. You might, at first, think that in amputating a limb ventilation would have nothing to do with the speedy recovery of the patient, this notion, however, would be a great mistake, as ventilation has more to do with it than any other thing.

The surgeons, during our late war, were fully aware of this, they well knew if they amputated a limb that the death or recovery of the patient depended more upon the air he breathed, than any other agent with which they had to deal.

I remember listening with much interest to the Surgeon General's description of a very difficult case of amputation, which he performed in the field in West Virginia, I think, and he kept the patient with him, (generally in a hospital tent,) and he was getting along most favorably; but was sent finally to one of the hospitals in Baltimore, which I think was an old hotel; soon after which he died. I heard the surgeons say afterwards that they scarcely could cut off a finger in that hospital but the patient would die.

They died from impure blood, they died for the want of ventilation, and this is simply the universal experience of every physician and surgeon.

If I were to scratch my finger, ventilation would have more to do with its healing, than all the salves and plasters I could put on.

It is a very common remark that a cut or wound will not heal because "the blood is out of order." Very sensible remark, too, and the quickest way to get the blood in order is to breathe nothing but pure air and plenty of it.

You have often heard of the woman that wanted some whiskey for a sore toe, but on being remonstrated with for drinking it right down instead of using it to bathe the toe, remarked—"It will soon get there." She was not so far out of the way, either, as we might suppose at first; it would soon get there, indeed, and the inflamed and poisoned blood, I was going to say, would do most as much harm as it does when it gets into the other end of the system; but perhaps that would hardly be possible.

You cannot live without breathing; you cannot live without eating; you cannot live *well* without exercise. These are the three grand essentials for health, comfort and happiness.

The breathing is of more than ten times the importance that eating is. By breathing pure air you can digest more food, and you require more to satisfy hunger.

Some of you may be surprised to hear me assert, that if you cannot get food you would die sooner by breathing pure air, than you would by re-breathing some of the foul poisonous air previously exhaled. I was led to consider this question by the very unexpected results of some experiments I tried last summer with some flies. I took six half-gallon jars, six quart jars, and six pint jars, making 18 in all, into all of which I enticed flies by covering them with bread, with a little molasses underneath. I intended to put two dozen into each jar, but they would not go in just to suit me, so some had 20, some 40 and some 60. Two of the bottles of each size, making six in all, I filled with my breath, and sealed up tight; two of each size I simply sealed tight, but filled with pure air, and the other six, two of each size, I covered with coarse netting, so as to allow of a free circulation of air and keep the flies confined.

It was in summer, and I closed them up at 6 P, M., the sun about an hour high, I observed their condition at intervals of an hour,

making a note on each bottle. At the end of the first hour those confined in the breath were very stupid, many of them tumbling about from side to side, and none able to fly. Those confined in the pure air were moderately lively, about half of them could fly from side to side, and were just as much at the bottom as at the top of the jar. But a very different scene presented as the others with the circulating air were examined, they were all crowded to the fresh air opening, their feet sticking up through the netting, and there they remained with much persistence, if driven away they would immediately return, and in one, there being more flies than room at the fresh air opening, they had to take turns standing at the window, which reminded me of what I observed at Nashville jail, which was so shamefully crowded and with so little air, that each prisoner was allowed just so many minutes to stand by the little hole that admitted the fresh air, and this was considered so great a privilege, each one waited with the greatest anxiety and impatience for his turn, and they would never miss, night or day.*

So it seemed to be a great privilege with these flies, but I suppose they did not take their turn with so much punctuality.

In two hours some of the flies in the breath seemed nearly dead; the others much the same. At ten in the evening no particular change.

Next morning, at six o'clock, no marked difference; those in the breath a little more stupid, and two or three apparently dead; one or two in the confined pure air about dead, on being put out in the bright morning sun they revived wonderfully; those with the circulating fresh air kept up a perfect humming, and the others revived very much; but few, however, of those in the breath, were able to fly even with this extra stimulus. At ten A.M., I went to town, and at five P. M. returned home. I expected to find all those in the breath dead, and those in the confined pure air about half dead, and those in the circulating pure air as lively as ever; but to my utter astonishment and disgust, I found every one of those in the pure air stark dead, not a vestige of life in a single fly.

Those in the pure confined air were about half dead, and nearly the same proportion of those confined in the jar with the breath. But they did not die even in these with that perfect regularity that I wanted them to do.

* I should state, probably, that upon reporting the condition of this jail to General Rosecrans, then commanding, he had it remedied.

That is to say, where there are twenty in a pint jar, and twenty in a quart jar, and twenty in a half-gallon jar, if those in the pint jar died in twelve hours, I expected those in the quart jar to die in twenty-four hours, and so on; but they did not observe any such regular rules in dying.

But, notwithstanding my great disappointment, I kept the jars and watched them. Those in the breath died a little the fastest; but very soon after I noticed another form of animal life in the shape of maggots, which soon attained the size of the original flies.

Now, as these bottles were perfectly clean and corked air-tight immediately after the flies entered, how did those maggots get there? I leave this for others to answer.

Some of these flies lived ten days, (there would be but one or two in a bottle that lingered so long,) the other animal life lingered some three weeks. These bottles, upon being opened, emitted a horrid stench.

But the bodies of the flies confined in the pure circulating air never had the least unpleasant odor, were never touched by any insect, and three months after their bodies were just as bright and clear as the day they died. Thus, those in the foul air lived ten times as long as those in the pure air. Now the practical lesson this teaches is what I before asserted, that when you breathe pure air you live faster, so to speak; you are much more lively; you use much more exertion; but all this exertion requires power, and universal power requires food.

Now, these flies in the circulating pure air no doubt used more exertion or did more work in the few hours they were living there without food, than did those which lived ten days—their bodies were so thoroughly used up, there was nothing but skin and bones left.

This explains what might otherwise seem a strong argument against breathing pure air.

We find some poor, delicate creatures living on to be thirty, forty, fifty, sixty and even seventy years old, and appear to be a perfect refutation of all regular physiological rules; but what sort of lives *do* they live? They cannot do a quarter of a day's work, they can scarcely eat a quarter of a full ration, and if they have existed to an old age they oft-times have scarcely done the work of a quarter of a lifetime.

And thus we find many poor people living in poor, unventilated

houses, *exist* sometimes to quite an advanced age, but they are often sick and feeble.

Therefore, when a person finds he cannot earn his living, or if he does earn it he is sure he cannot get sufficient food to eat, he had better imitate the hybernating animals as nearly as possible, and get into some close, unventilated place and lie down in perfect quiet and repose—and not fret at all and he will then be able to get along on as little food as the most angelic of our fashionable belles could desire to boast of.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

(Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst., Troy, N. Y.)

(Continued from page 351.)*

My last paper on the present subject, closed with a proposal to set forth a typical curriculum for a *scientific* institution, possessing a university character, in the American sense, of containing a circle of professional or technical schools, based upon a fundamental disciplinary course, mainly composed of scientific studies. But, in writing, as now, in a summer resort, away from necessary material for reference, it is impossible to do this. Besides, it appears by trial, that various preliminary matters yet remain, to be touched, at least.

We must first introduce a few elements of philosophy, yet so condensed as to be, so to speak, conveniently portable for ready use.

Fact is whatever really *is*, in distinction from what *might be*, or *is supposed to be*.

The two great comprehensive and antagonistic facts of existence, are good and evil.

Good is perfection of *structure*, *action* and *possession;* or, in other words, of *being*, *doing* and *having*. External possession, or having, is *objective* good, and in its perfection is the source of the utmost degree, and highest kind of the *enjoyment* derivable from external things. It is thus a natural stimulus, or source of inspiration, which reacts upon the *being* and thence upon the *doing* of

* *Correction.*—On p. 349, line 12, read "industrial."

the happy possessor. The *acquired* mental powers resulting from worthy *doing*, are one's *subjective having*, and the most precious of his acquired possessions.

BEAUTY is not something else than good, nor a mere attribute of good, but a certain *relation* of it. It is, we venture to say, *good, considered as spontaneously self-expressive*, whether living or abstract, spiritual or material, partial or complete. Thus, when we say that one's spirit or life is full of beauty, we mean that it is not something unknowable, hidden, and incapable of self-revelation, but something open and readable, which of *itself alone*, that is, freely, unconsciously, reveals itself as good.

The rare subtlety and elusive delicacy of the idea of beauty makes it unsafe to risk a bare definition of it, unsupported by illustration. We therefore dwell upon it for a moment in the latter way. And as spiritual beauty is of the highest order, a simple study from life may afford an acceptable illustration.

The ideal of a man is that he should be the perfected, the ripened sum of all his previous states. When, then, I look into the face of my speaking friend, and there clearly see retained, amidst and under firmer lines and tones of growing maturity, all the freshness of life and ardent delight in it, and the truthfulness and gentleness of sunny childhood and gay boyhood, I delight in the beauty consisting in the spontaneous expression, in his case, of the ideal good mentioned; and, as in the definition, the degree of beauty depends on the fullness with which that truth reveals itself, in this case, on the extent to which the man has retained his true boyhood in and as part of his true manhood.

In like manner, when any inanimate object is called beautiful, it is meant that it suggests or expresses elements of good actually or possibly in the *being* and mental or manual *working* of the designer and maker on in life generally. Thus, a partially concealed discord, naturally leading, according to the laws of harmony written upon the mind, to a full, rich, and perfect concord, expresses the *good* of temporary and unpromising conflict, resolving itself to the heart of hope and faith into a happy conclusion. Again: the horizontal direction, with the great weight of the main branches of an oak, suggest the *good* of vigorous, inward might, abundantly adequate for self-support under the greatest stress of circumstances and pressure of outward conditions. Moreover, both of these expressions of particular forms of abstract good, or good elements of being or life, further suggest a living one; as the composer of the harmony by

whom the elements of good expressed were conceived of and appreciated, or in whom, as in the creator of the oak, they resided.

TRUTH is good considered as universally agreeing with itself in all its forms, so that when one form exceeds the point up to which it graces or assists some higher good, it then ceases to be a good. Otherwise: truth, abstractly, is agreement with fact; in life, it is thought, action, expression, agreeing with fact.

RIGHT is the means for the attainment of good; the path to attainable good. To handle any tool in the *right* way, is to handle it so as to accomplish what the tool is meant to accomplish. And actions, generally, are *right* when they serve to perpetuate or produce any real good.

Thus *good* is the grandest and most central of all abstract terms, and one to which the trio, *true*, *beautiful* and *right*, cling in close and happy relation.

Passing now from these abstract elements to the life in which they are to be realized, we have to consider the outlines of the constitution of man, that we may have in mind some guiding principles in composing a course of studies for the training of his being.

Man is primarily a union of matter and mind, of body and spirit, and *such* a union that the highest earthly well being of each is involved in that of the other. Moreover, as the bodily wants are earliest expressed and most immediately imperative, we have in this fact the sure ground for the instinctive demand for the sound body first, as the due lodgment and instrument, too, of the sound mind.

The body being at once the temple and servant of the ministering and governing spirit, the elements in the latter are chief in interest and importance.

In the spirit there is found, fundamentally, *conscious life*, with *reason*, or the sense of first truths, or axioms and primary ideas, as of space, &c., for its appointed guide, and will, or the power of choice, as its appointed sovereign; that is, in both cases, as against the mere declaration or dictation or interference of other like spirits, but ever in unmingled deference to the Supreme Creating Spirit.

Within the reason are *common sense*, by which, for lack of another term, is here meant the sense of the distinction of true and false; *taste*, or the sense of the distinction of beauty and ugliness; and *conscience*, often expressly called the moral reason, or the sense of the distinction of good and evil, and of right and wrong as the means to each.

(To be continued.)

Bibliographical Notices.

Lessons in Elementary Chemistry, Inorganic and Organic. By Henry E. Roscoe, B. A. F. R. S., Prof. of Chemistry in Owen's College, Manchester. Published by William Wood & Co., 61 Walker Street, New York. Lindsay & Blakiston.

This work is a re-print from the English edition, of which a brief but rather *severe* notice was made in this *Journal* some time since, by one of our contributors.

The present publishers have followed, in style and general arrangement, the foreign edition, but seem to have taken more care with the execution of the work. Thus, while the engravings are as unartistic and rough as before, the paper and printing are excellent.

The book is of a convenient size, is neatly bound, and very suitable as a text-book on chemistry, according to the new theory and nomenclature.

It is arranged somewhat on the inductive method; laws and theories being distributed here and there, as developed by the facts and reactions discussed. According to our own notion, this is less efficient for purposes of instruction, than a systematic arrangement of laws first, and facts afterwards; but this is a subject on which great diversity of opinion exists, and our author has abundant support in the way of example in his view of the subject. For those desiring a concise compendium of elementary chemistry in its new shape; this work will prove very useful.

A System of Instruction in the practical use of the Blow-pipe; being a graduated course of analysis for the use of students and all those engaged in the examination of metallic combinations. Second edition. With an appendix and a copious index. By G. W. Plympton, A. M., Prof. of Physical Science in the Polytechnic Institute, Brooklyn. Published by D. Van Nostrand, 192 Broadway, N. Y. J. B. Lippincott & Co.

In addition to the title given at length above, it is only necessary to state that this book is brought out by its publishers in a good substantial form, and that it differs from the classical works on this subject, such as those of Berzelius and Plattner, chiefly in a greater simplicity and compactness, and in the introduction of the latest

discoveries and new modes of testing, which have been applied in blow-pipe analysis.

The work is, as its author states, chiefly a compilation from Scheerer and Plattner, which shows it to be reliable, and is evidently well arranged; while the fact of its reaching a second edition in a year, speaks highly for its usefulness and value in the eyes of those most interested.

The Gas Works of London. By Zerah Colburn, C. E. Published by D. Van Nostrand, 192 Broadway, New York. For sale by J. B. Lippincott, Philadelphia.

This little book of some 86 pages, is of course far from being a thorough treatise on the important industry of gas manufacture, but it does contain much special and exact information on the details of the process, not included in any other book.

It is, in fact, a reprint of certain articles published in *The Engineer* during 1862, with additions and re-arrangement. Being thus prepared by one on the ground, and furnished equally with the means of acquiring exact information, and the ability of giving expression to the facts obtained, it could not fail to be what its perusal demonstrates it, a work of great value to all engaged in the business of which it treats.

A Treatise on the Metallurgy of Iron, containing outlines of the history of iron manufacture, methods of array and analysis of iron ores, processes of manufacture of iron and steel, &c., &c. By H. Bauerman, F. G. S., Associate of the Royal School of Mines. First American edition revised and enlarged; with an appendix on the Martin Process for making steel, from the report of Abram S. Hewitt, U. S. Com. to the Universal Exhibition. Published by D. Van Nostrand, 192 Broadway, New York. For sale by J. Pennington, Philadelphia.

We can cordially recommend this volume as a full and concise discussion of the subjects enumerated above. Containing but 400 small octavo pages, it of course does not compare in fullness of detail and extent of discussion with such a work as Percy's; but for that very reason will commend itself to many who do not care to study the *history* of the various improvements in iron manufacture, but are contented with the results, and to whom the relatively trifling cost of this work would be an object.

The Institutes of Medicine. By Martyn Payne, A. M. M. D., L. L. D. Eighth edition. Harper & Brothers, New York. Lindsay & Blakiston, Philadelphia.

This work is one of great size, containing 1,145 quarto pages, and that it should have reached eight, and in fact, nine editions (two editions notably different, having by some chance been published as the seventh), is a valuable and irrefutable testimony to its worth.

The subjects treated in this work are not such as we feel ourselves competent to discuss, and we therefore leave the matter with the above statement as embodying the practical and sincere judgment of those most competent and interested during past years, and simply add that the work has been put in excellent and substantial form by its present publishers in this edition, with respect to paper, typography and binding.

The Merchants' and Bankers' Almanac for 1868. Price two dollars. Published at No. 41 Pine Street, New York.

Contains the monthly prices for forty years, at New York, of the following articles:

Bar iron, sheet iron, pig iron, pig copper, anthracite coal, coffee, cotton, wool, wheat, rye, corn, oats, hops, molasses, sugar, pork.

The grain products (quantity, acreage and value) of every State in the Union—corn, wheat, rye, oats, barley, buckwheat, potatoes, hay and tobacco—years 1865, 1866.

Also, the monthly prices of ninety staple articles at New York, 1867.

Also contains:—1. List of 1,650 National Banks; 300 State Banks; 1,400 Private Bankers in the United States; Banks and Bankers in Canada; 1,200 Bankers and Brokers in New York City, including names of members of the New York Stock Exchange. 2. The Open Board of Brokers. 3. The Gold Board. 4. The Mining Board; Annual Reports on Banks, Coinage, and ninety Staple articles; Capital, Circulation and Profits of each Bank in New York City. Also, a list, recently compiled, of the Marine, Fire, and Life Insurance Companies in the United States (eight hundred and twenty-seven in number), with the names of President and Secretary of each, and the capital (or assets) of each in 1867. The daily price of Gold at New York, 1862 to 1867; Alphabetical List of 2,000 Cashiers; and Engravings of New Bank Buildings.

A COMPARISON *of some of the Meteorological Phenomena of* JULY, 1868, *with those of* JULY, 1867, *and of the same month for* EIGHTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	July, 1868.	July, 1867.	July, for 18 years.
Thermometer—Highest—degree	98·0°	91·0°	101·00°
" date	14th.	4th.	17th, '66.
Warmest day—mean	90·50	85·67	92·33
" " date	14th.	4th.	17th, '66.
Lowest—degree	65·00	58·00	53·00
" date	28th.	14th & 19th.	2, 3, '62; 3, '57
Coldest day—mean	71·50	66·67	59·70
" " date	27th.	20th.	3d, '57.
Mean daily oscillation	13·32	14·69	15·42
" " range	3·13	3·99	3·81
Means at 7 A. M.	77·26	72·00	73·99
" 2 P. M.	86·60	81·27	83·70
" 9 P. M.	80·79	75·00	76·58
" for the month	81·55	76·09	78·09
Barometer—Highest—inches	30·163	30·249	30·249
" date	1st.	14th.	14th, '67.
Greatest mean daily pressure	30·141	30·243	30·243
" " " date	1st.	14th.	14th, '67.
Lowest—inches	29·623	29·665	29·443
" date	25th.	21st.	19th, '51.
Least mean daily pressure	29·719	29·698	29·462
" " " date	25th.	21st.	30th, '56.
Mean daily range	0·064	0·097	0·092
Means at 7 A. M	29·962	29·941	29·844
" 2 P. M	29·928	29·912	29·815
" 9 P. M	29·942	29·916	29·831
" for the month	29·944	29·923	29·830
Force of Vapor—Greatest—inches	0·911	0·925	0·983
" date	12th.	6th.	26th, '54.
Least—inches	·507	·321	·255
" date	27th.	18th.	22d, '64
Means at 7 A. M	·705	·552	·614
" 2 P. M	·732	·543	·610
" 9 P. M	·752	·608	·644
" for the month	·729	·568	·623
Relative Humidity—Greatest—per cent	90·0	91·0	97·0
" date	23d.	27th.	Often.
Least—per cent	39 0	32·0	26·0
" date	13th.	3d & 18th.	23d, '56.
Means at 7 A. M.	75·3	68·9	72·3
" 2 P. M.	58·3	50·5	52·8
" 9 P. M.	71·6	69·2	70·0
" for the month	68·4	62·9	65·0
Clouds—Number of clear days*	5·	14·	7·6
" cloudy days	26·	17·	23·4
Means of sky covered at 7 A. M	72·6 per ct	52·2 per ct	58·7 per ct
" " " 2 P. M	65·2	59·3	59·3
" " " 9 P. M	64·5	43·2	42·8
" " for the month	67·4	51·6	53·6
Rain—Amount—inches	2·63	3·030	3·534
No. of days on which rain fell	9.	12·	10·9
Prevailing Winds—Times in 1000	s 15°15′ w. 131	N 69°35′ w. 2(8	s 75°39′ w. 166

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] OCTOBER, 1868. [No. 4

EDITORIAL.

ITEMS AND NOVELTIES.

Soda Water Apparatus.—We spent an evening very pleasantly, some weeks since, at the Conversazione of the American Pharmaceutical Society, which was held in the new building of the College of Pharmacy in this city. Among the many pieces of apparatus and products of manufacture exhibited on that occasion, nothing will, we think, be of more interest to our readers, than the various machinery connected with the manufacture and storage of soda water (so called), or more strictly water holding in solution carbonic acid under pressure. The most complete collection of this apparatus, was that sent by Mr. John Matthews, of New York, and we shall proceed to describe some of the more prominent features and interesting novelties there represented.

When the father of Chemistry, Dr. Priestly, writing about 1772 (see his "Experiments on Different kinds of Air," Vol. I. p. 52), sug-

gested the application of water, charged with carbonic acid and with salts in solution, as a substitute for the natural waters of Pyrmont and Seltzer, and also the charging of wines with the same gas, he could certainly have little imagined to what this fertile idea would grow. Grow, however, it did, in all parts of the world, and in none more than our country, where, as an illustration, it has been computed that in New York alone, on a hot summer's day, more than one million of bottles of this material are consumed.

The forms of apparatus which are in use for the production of soda-water, may be divided into two classes, those in which the carbonic acid is first collected in a gas holder, and then by means

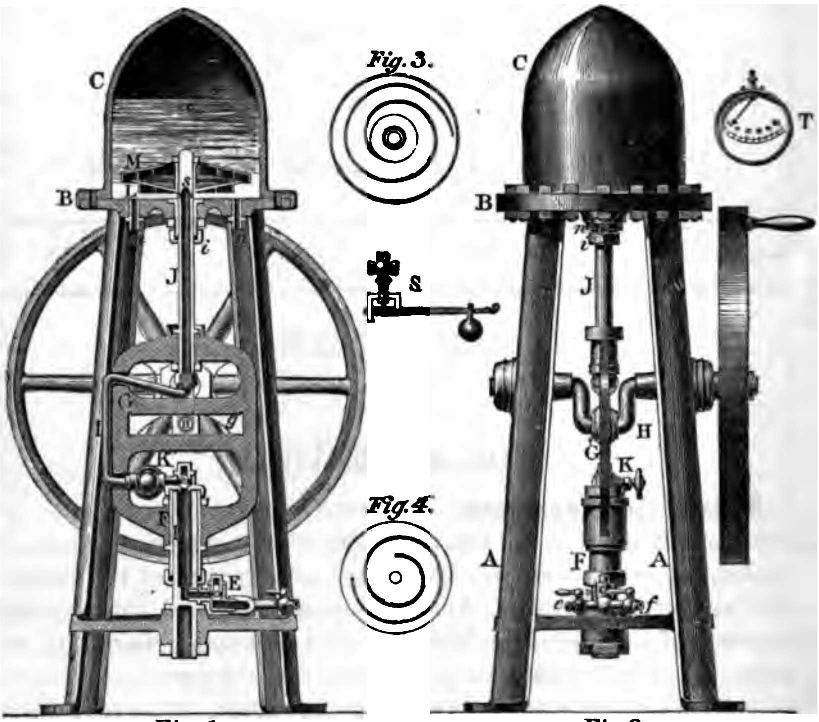


Fig. 1. *Fig. 2.*

of a pump forced into a strong vessel, in which it is absorbed by the water there placed; and those in which the gas is generated in strong vessels, in which it establishes a great pressure by its expansion in being evolved from the ingredients used, and then is simply allowed to flow into the charging vessel, where it comes into contact with the water and is absorbed by reason of the self-generated

pressure above mentioned. The first of these is the process generally followed abroad, while the second is that employed in this country. Mr. Matthews produces apparatus of both kinds, which we will describe in order.

In the first place, as regards that which may be called the European apparatus, and which in its original form, will be found very well described in the *Chimie Industriel*, of Payen, but which in the present case, has received many improvements, leading to increased strength, economy, durability, and the avoidance of leakage, as will be understood from the following description:—

In the accompanying engravings, Fig. 1 is a vertical section, and Fig. 2 is a perspective view of the apparatus, bearing at its top a table, B, on which is secured the condenser or reservoir, C, for holding the carbonic acid gas and water mixed therein, and which reservoir, by the present improvement, is made free from all joints below its water-line, the average level of which is indicated by *a* in Fig. 1. Inserted through the table, B, may be tubes, *m* and *n*, for attachment of the usual bottling-nipple, the pressure-guage, T, and safety-valve, S. Connected with the lower portion of the frame is a stationary hollow plunger, D, communicating below by a branch *b*, with a valve-box, E, the valve, *c*, of which is arranged to open upwards and control the suction by a passage, *d*, through branches, *e* and *f*, one serving as the induction-pipe for the water, and the other for the carbonic acid gas, which may be received from any suitable reservoirs. F is the working cylinder which plays up and down, over or outside of the stationary plunger, D, and is connected so as to be operated by a reciprocating yoke, G, which is driven by any suitable power through the crank, H, and having play in an oblong slot, *g*, of the yoke. The cylinder, F, is provided at its upper end with a delivery valve, *h*, which in the descent of the cylinder allows of the gas and water entering in at the up-stroke of the cylinder, through or beneath the valve, C, of the plunger, D, to be forcibly expelled through a branch, I, and vertical discharge-pipe, J, through perforations, S, into the reservoir, C. The plunger, D, and cylinder, F, act as a lower guide to this reciprocating arrangement, while the pipe, J, working through a stuffing-box, *i*, in the table, B, of the reservoir, operates as an upper guide.

K is a valve for shutting off communication between the pump and reservoir C, when necessary for repairs of the valves or other purpose, while the reservoir is full or under pressure. The gas and

water forced out through the perforations, S, during the action of the pump, are admitted to the reservoir, C; and to effect the mixture of the gas and water, two volutes, L and M, also shown in Figs. 3 and 4, are attached to the reciprocating discharge-pipe, J, where it projects within the reservoir, C, the volute, L, as it rises, causing the gas to work spirally outwards and passing up under the upper volute, M, which works in an opposite direction, and finally escapes by a central orifice. By means of these volutes, an effectual agitation of the water is kept up, and a thorough mixing of the gas with the water produced as they are worked up and down within the reservoir, C.

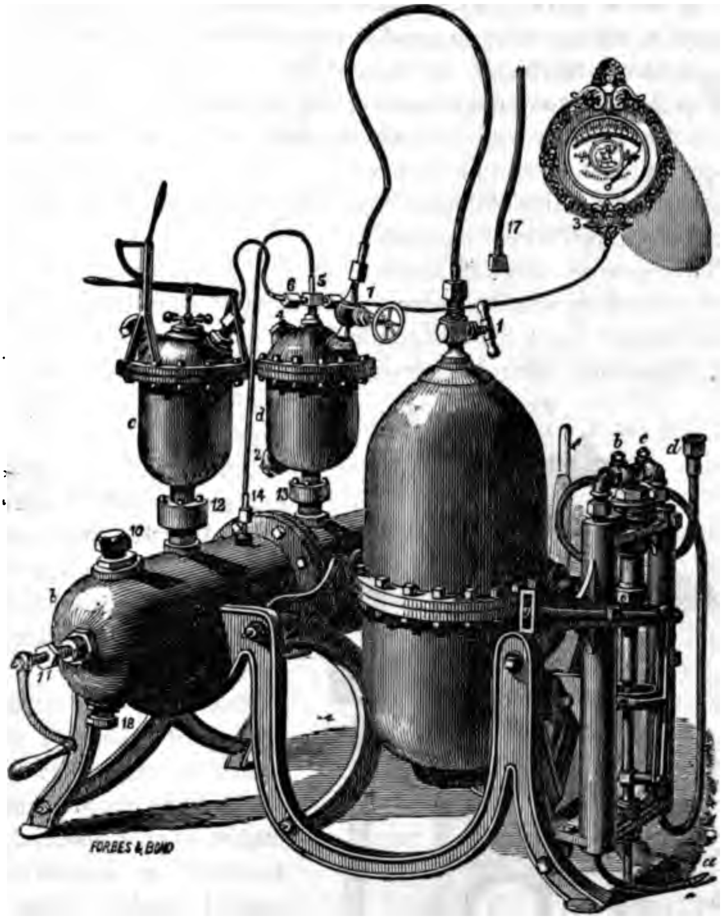
Among the advantages which are claimed for this improved apparatus, are dispensing with all joints above the water-level in the reservoir, C, the importance of which will be readily understood, when the great pressure of the gas contained in the reservoir is considered, and the difficulty that exists in making a joint, above the water-level, tight against the escape of gas; the pump, aided in its descent or discharging stroke by the pressure of the gas or gas and water, contained in the reservoir, acting on the head of the discharge-pipe; the pump is aided in producing further compression or condensation by the pressure previously effected by it, as where the pump is merely used to force in the water, the same, S, assisted in supplying the reservoir, C, by the pressure of the gas separately admitted. In addition to those advantages, is the great simplicity of the working parts and steadiness of the action as produced by the reciprocating cylinder, F, on the plunger, D, and discharge-pipe, J, through the bottom of the reservoir, the distance apart of the guides to the pump aiding in this result, and the reciprocating action of the pipe on the connection, J, in a longitudinal direction being preferable to a rotary one for working the agitator, as offering greater security against leakage at the stuffing-box.

The process which we may call the American method, is also illustrated by another of the forms of apparatus constructed and improved by Mr. Matthews, of which we have a very clear representation in Fig. 5.

The goblet-shaped vessel to the left of the cut is charged with sulphuric acid (commonly called oil of vitriol), which by means of a valve operated by the lever shown at the top, can be made to flow as required through the connecting neck, 12, into the large cylindrical vessel below.

In this vessel is previously placed (by means of the opening at 10 closed by a screw plug) a quantity of pulverized marble (carbonate of lime), or other alkaline carbonate, by reaction with which the sulphuric acid forms sulphate of lime, or of the other base, and

Fig. 5.



sets free the carbonic acid, before in combination. This carbonic acid gas then passes by the tube 14 into the second vessel, *d*, where it bubbles through a small quantity of water, by which it is washed cléar of acid spray, or other impurity.

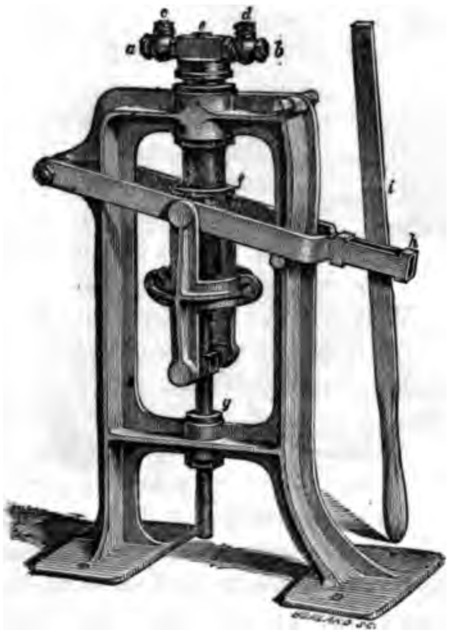
At the point 5, where the tube enters this vessel, two branches are taken off, one to the guage (3), which indicates the amount of pressure produced, and so prevents risk of accident, and the other,

c, to the sulphuric acid vessel, to establish an equilibrium of pressure, so that the acid may flow through the valve. From the washing vessel, *c* (which only rests on the cylinder, and has no communication with it at 13), the gas passes into the fountain or large eliptical vessel to the right, which has previously been filled two-thirds full of pure water, or with such a solution or liquid as it is desired to charge with gas, and is there absorbed by the fluid; this action being facilitated by a brisk rocking of the vessel on its trunnions, and consequent agitation of its contents.

To the extreme right, is seen a pump, by which water may be forced into the fountain even when it is under pressure, from a remaining quantity of charged water and gas, or by which gas may also be pumped when required.

These pumps, of which a more complete drawing is shown in Fig. 6, are of a very simple, enduring and efficient character, and beside their regular use, have been applied with great success in compressing oxygen and illuminating gases into iron reservoirs, for use in the production of the lime light.

Fig. 6.



Another of the ingenious contrivances which were exhibited by Mr. Matthews on the occasion above mentioned, was the arrangement of bottles for liquids under pressure.

Every one has remarked the great waste of corks which is constantly going on, and the constant depreciation of that material, (the result of an excessive demand,) causing great loss by leakage. This very serious difficulty has been met in the following way. A glass cork, with a head of india rubber, as shown in Fig. 7, is introduced into the bottle, which is then filled with the

soda water in an inverted position. The stopper thus lies with its glass point downward in the neck of the bottle, and as soon as the external pressure, by which the liquid is introduced, is withdrawn, the internal pressure forces the stopper out of the neck until it is arrested by the projecting rubber head, which makes tight joint in the neck of the bottle. When the bottle is to be opened, a smart blow upon the projecting stopper, (see Fig. 8), the bottle standing erect, drives it down inside, and the liquid may be *all* poured out, or its flow arrested, by inverting the bottle, when the stopper will again fall into place.

Fig. 8.

Fig. 7.

Our limits forbid us to say more, here, but in our next number, we will describe some other valuable improvements.

Centrifugal Pumps.—In a paper read at the late meeting of the British Association by Mr. Gwynne, on the above subject, it was stated that practice had shown that the most important requisites to secure a successful and economical result from the use of such apparatus, were the following: In the first place, uniformity of cross section in all passages and connections; and secondly, the avoidance of all sudden changes of direction. With regard to the first point it had been shown by experiment, that not only were contractions detrimental to the rapid discharge of a liquid through a pipe, as might be assumed naturally, but that enlargements were likewise prejudicial. Thus the investigations of Bossict had shown, that in a case where 4 cubic feet of water were discharged by a regular pipe in 109 seconds, when a tube of the same size, but with one enlargement was substituted, it required 147 seconds to discharge the same volume of water. With three enlargements, 192 seconds were required; and with five enlargements 240 seconds. This interference is undoubtedly due to the eddies and counter-currents as well as to changes in velocity which are induced by such irregularities.

The Geoselenean.—At the present day, when the range of our knowledge on all subjects is so rapidly increasing, anything which honestly facilitates the acquirement of information in those branches which are essential to a sound and liberal education, is of great value, because it renders possible the attainment of more than could otherwise be learned, and makes it possible for the general student

to keep up with the progress of the age. For this reason we are glad to draw attention to a new instrument, which is a modification of the well known Orrery devised by Mr. James G. Moore, and

embodying many features and the means of clearly illustrating many facts, not found in the old instrument.

This apparatus exhibits, by an absolute physical demonstration, many of those complete phenomena connected with the motion of the moon, earth and planets, which can thus be appreciated almost at a glance and adhere spontaneously in the memory, but which, without such aid, can hardly be grasped by ordinary minds, even with persistent effort, and are then likely to be as difficult to retain in the memory, as to secure.

The accompanying figure shows the general appearance of the apparatus, which it would be out of place for us to descrbe, since its essential feature is, as we have stated, the doing away with descriptions by exhibiting the very phenomena in question. (See advertisement on another page.)

Mr. Eads' Report on the Illinois and St. Louis Bridge.—(*ERRATA.*)—In the notice of this report, which appeared in our last issue, a strange mistake occurred, in a curious way. We marked on the margin of page 51, near the top, for insertion, the following:—

"Enough is known, however, to assure us that the limit of elasticity is higher in compression than in tension, and if it were no greater, we cannot avail ourselves of more than 50 or 60 per cent. of this limit in tension, while the whole of it can safely be utilized in compression." The ink, however, soaking through the leaf to the other side, caused a similar mark to appear upon another sentence exactly corresponding in position and length, and, moreover, in general style and wording, except that it conveyed an almost opposite idea. This side of the leaf was, by ill luck, copied in place of the other, and we are thus made to stultify our assertion by the quotation of what precisely *does not* prove it.

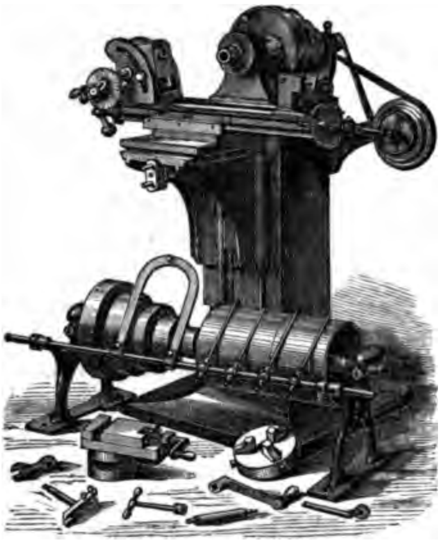
If our readers will, however, substitute the above quotation for the one found on page 150, our common sense will be vindicated.

We also observe that our compositor has thought good to insert an "s" in the word "decrying," and thus again invert our meaning. We *have* every wish to "descry" Mr. Eads' bridge spanning the Mississippi at an early date.

Universal Milling Machine of the Brown & Sharpe Manufacturing Co., Providence, R. I.

In the accompanying wood-cut, we illustrate this piece of apparatus, of which we have heard very favorable accounts from many

of our Philadelphia machinists who have it in use, among whom we may enumerate Messrs. Wm. Sellers & Co., Bement & Dougherty, Cresson & Smith, Morris, Tasker & Co., Henry Diston, and others.



This machine is adapted to the making of many tools required by gun makers and machinists, such as twist-drills, mills of all shapes, with straight or spiral teeth, and cutters for gear and other work. It will, moreover, cut a tapering or conical mill, with right or left hand spiral teeth, and will supply the place of the common index milling machine.

In the upper part of the cast iron frame is the main arbor, made of steel, with bearings, which may be adjusted to take up wear.

On the front of the frame slides a knee, controlled in vertical movement by a screw operated by a bevel gear and crank in front, and having also a stop-motion, which limits the rise and fall of the knee, and thus regulates the depth of the milling. On the top of the knee is a slide moving toward and from the main arbor, and on this is a rotating plate, with a graduated arc and means of clamping firmly to the slide.

In this also slides the long carriage, shown in position by the cut, which is operated by a long screw and handle at one end, which is also capable of being driven from the feed cone by a small shaft with two Hook's joints. By this means the carriage may be fed at any angle. At one end of the carriage, the right side of the cut, is a stand, sliding in a groove, with a centre in its top.

At the opposite end is seen a head, having a hollow arbor, in which a centre can be placed. Between this and the centre of the stand, the work to be milled is placed, and any spiral or the like can be made by means of the index on the side of the head, which is connected with the arbor by two mitre gears, a worm, and a worm wheel. The arbor in this head can also be connected with the screw that gives motion to the carriage.

The interior part of the head supporting the arbor can be raised and set to any angle, thus rendering the cutting of tapering spirals as easy as straight ones.

A small universal chuck (shown on the ground in the figure) is made to screw on the arbor, and is useful in cutting face mills or other like work.

Shaw's Lock-Nut Washer.—Among the many attempts to secure nuts upon bolts, one of those which combine simplicity and efficiency in an eminent degree, is that mentioned above. This device consists of an ordinary plain washer constructed of steel, cut through one side, and bent so as to represent one coil of a spiral, the flat edges of which come first in contact with the nut. These are made sharp, and the coil is in a direction that permits the nut to revolve over it when being made tight; but the edge of the washer catches into the nut when turned back, with sufficient power to prevent the nut from turning on its own account, though it yields to the force of a wrench.

The advantages claimed for this method of locking nuts are freedom from any ragged points to surround the nut; the rendering use of two nuts no longer necessary; the dispensing with pins and keys: and last, but not least, the doing away with destructive riveting of bolts, thus offering, in many cases, at once a better and a cheaper method. Those connected with railroads will be quick to perceive the advantage of this improvement as one compatible with safety and economy. Messrs. Furbush & Gage, Office 118 Market Street, Philadelphia; Manufactory, Camden, N. J., are the manufacturers of this article for railroads and other purposes, from whom any further information can be had.

Dynamite.—The wonderful results, as regards increase in progress and reduction of cost, which have been attained with Nitro-Glycerine make its employment in all extensive blasting operations of the greatest importance; but, at the same time, the terrible and in many cases inexplicable cases of explosion during or after transit which have occurred within a short time, do and ought to check this otherwise desirable application of a new agent whose power is unparalleled.

Under these circumstances, we read with pleasure, an account which was given before the British Association by Mr. Nobel, of a simple modification, or, rather mixture, of this substance, which seems likely to rob it of its dangerous, while leaving unimpaired all its useful, properties.

When nitro-glycerine is mixed with one-fourth of its bulk of porous silica, we are told that a soft solid, somewhat of the consistency of tempered clay, is produced, to which the name *dynamite* has been given. What this porous silica may be, we are not told, though it is evident that a mistake has been made in some foreign journals, where it is described as sand or gravel, 25 per cent. of which, added to such a liquid as nitro-glycerine, would certainly not bring it to the condition described. The great element of security which is introduced by this simple change of form, consists in the avoidance of leakage, which it appears in practice almost impossible to prevent, while the substance is in its fluid state, and which, by exposing this material in a shape most favorable to all decomposing actions, to the influences of the air, of heat, of percussion, and of friction, may be regarded as the primary cause of all the terribly destructive accidents which have occurred with this material.

This will explain the strange inconsistency which all have no doubt remarked between the reported properties of nitro-glycerine, as described by those most familiar with its manufacture and use, and the actual properties which it has occasionally exhibited. In fact the two classes of properties have belonged to different substances. The first being those of nitro-glycerine, the latter of some as yet unknown modification, induced by exposure to such influences as we have enumerated.

As for the safety of the explosive in its new form above described, the following experiments made at Glasgow, and repeated at Merstham, will say much. A box containing 8 lbs. of dynamite (equal in effect to 80 lbs. of powder,) was hurled down from a height of 60 feet upon the rock below. The box was broken by the fall, but its contents was not exploded. Another similar box was then placed on a fire, where it slowly burned away.

At Stockholm a yet more severe test was applied, for a weight of 200 lbs. was dropped, from a height of 20 feet, upon a box of dynamite, which it smashed without exploding.

While thus sluggish in its action, and, as it were, unwilling to be roused into a display of its force, its ability, when the proper stimulant to exertion has been applied, may be estimated from the following experiment:—

A cylinder of wrought iron was prepared, eleven inches in diameter and twelve inches long, with a hole one inch in diameter

along its axis. Six ounces of dynamite were introduced into this hole, without any tamping at either end, and fired by a fuse, when the cylinder was split into two pieces, which were violently hurled to a distance.

That such an explosive as nitro-glycerine should effect a great saving of cost as well as time, in all mining operations, will be evident if we reflect that cost of *introducing the explosive* by means of drilled holes is enormously greater than the cost of the explosive itself. When, therefore, we have, as in this case, a substance which in the same bulk concentrates a ten-fold effect, we see that the same amount of *expensive* labor will obtain a ten-fold result, while the increase in cost will be only in the *least expensive* item.

In fact, from a number of cases cited, it appears that about 25 per cent. of the entire cost of mining is saved by the use of this material, while the increase in the rate of progress sometimes amounts to 87 per cent., as in a long tunnel through Stockholm.

The importance of this saving in an extensive piece of tunneling requiring large capital, which earns nothing until the work is finished, is enormous, as we may see by considering the case of the Mt. Cenis or Hoosac tunnel.

The use of nitro-glycerine has been prohibited in Belgium and Sweden, but this regulation, it has been decided, does hot apply to dynamite.

Watering Roads with Deliquescent Salts.—It is stated in our excellent cotemporary, *Engineering*, that this process has been attended with excellent success, in London, during the summer months. Along Baker St. Portman Square, where the experiment was tried, it had given the greatest satisfaction to all the residents; and even on Sundays, when all watering of streets was discontinued, this locality enjoyed a clear atmosphere, while the neighboring thoroughfares were clouded with dust.

Bleaching by Ozone.—Under the heading of "A Doubtful Electric Item," we find in *Engineering*, allusion made to a report, that works had been erected in London, where sugar was to be bleached by a current of electricity. From a gentleman interested in the subject of sugar refining, who has just returned from England, we learned the actual state of the case, namely, that works were erected to carry out the process much ventilated in the foreign journals about a year since, in which ozone was to be developed in large quantity by passing air over a series of plates electrically

charged, and then used as a bleaching agent. On the small scale, this process operated with marked effect, but when attempted on a commercial scale, failed entirely, for causes unknown, but such as rendered an adequate development of ozone impossible. A. Wilde's magneto electric machine was employed as a source of electric force.

Editorial Correspondence.

FIRE PROOF BUILDINGS.

NEW YORK, *September*, 1868.

FIRE proof construction has become a matter of such necessity, especially in our older cities, that it is interesting to note the improvements, from time to time instituted, and how they are carried out. Any method tending to cheapen such buildings, is an invitation to their still further introduction, and an invitation that many real estate owners would avail themselves of. Under the present method of design and execution in this city, fire proof building is such an extravagant luxury, that rarely any private party can indulge in it, leaving such desirable improvements in the hands of wealthy corporations. Of course such a mode of building always must be more costly than where timber is used; but there is no reason in the world why it should present such an item of expense as in the City of New York. As yet few, comparatively, have been built, but many more are wanted and would be built, could owners be brought to believe that the examples before them, and from which they naturally form their opinions, are monuments of a shameful and wicked extravagance.

Iron is a material of infinite service, when properly and intelligently used, but a very dangerous material in the hands of ignorance or dishonesty. Its nature is such that we can more nearly work to its theoretic limits than can be done with any other material of constructions. The specific gravity of iron is so high that all used over and above what is really required for performance of duty, rolls up very rapidly a very costly excess. It is of very recent date that solid rolled beams of wrought iron have been used

for floor joists, before which time cast iron beams had been largely used, especially in England. Many accidents proved their unreliability, and beams built of plates and angle irons were substituted. In this country, the Cooper Institute was the first thoroughly fire proof building ever built, the beams for which were rolled at Trenton. These beams were nine inches deep, and were rolled from a single "pile," and it seems were necessarily about the largest beams that could be made by that method of piling. Not long after, Mr. Jno. Griffin, of the Phœnix Iron Co., invented and patented a plan by which beams could be solidly rolled up to at least twenty inches deep, and as long as would, in any event, be required. Mr. Griffin's invention consisted in rolling flange-bars separately, piling the plates to form the web between them, and then rolling and welding the whole mass together. It may be interesting to note that this process was pirated by the English manufacturers, and is in vogue with them to this day. It is, perhaps, the only method by which beams of large sections can be successfully made. We believe, in Pittsburg, they profess to make their beam piles by placing channel bars back-to-back, and thicken up the flanges, when desired, by piling plates on the top and bottom. At present, rolled beams are manufactured in this country, at Phœnixville, Buffalo, Trenton and Pittsburg. The two former make beams under the Griffin Patent, running through a list of sizes from five inches up to fifteen inches in depth, and, perhaps, make the greater proportion of beams used in this country. Trenton and Pittsburg works use different piles, the former endeavoring to compete with Buffalo and Phœnix by means of the old manner of piling, the latter using channel bar piles. Neither of these works, so far as we know, have been very successful in making beams over ten and twelve inches in depth. The supports for beams and girders have been always cast iron columns; but the wrought iron hollow columns, described in a former volume of the *Journal*, are gradually being appreciated. A building may be fire proof, and yet not indestructible. For example, a building may be filled with a combustible material, which, burning with an intense heat, will so unequally strain the the iron supports and flooring, that they must yield and carry with them to destruction everything under their influence. This is especially true where cast iron columns are used, which, when overheated, become as brittle as glass, and shiver, like glass, to atoms, should water be thrown upon them. Such columns will

stand no great tension, or any unequal straining, and ought to give place to wrought iron ones, especially in warehouses or other buildings used for general storage purposes. Office buildings not being subject to the conditions of a warehouse, can have cast iron columns to support the girders, and with good advantage. Attempts have been made to arrange a water circulation in the interior of columns to keep them cool in case of fire among store goods, but we have heard of no success attending the effort. There is one thing certain, and that is, any fire proof building, intended for storage purposes, should have the iron construction, as far as is possible, a wrought iron one. And it is desirable that even wrought iron should be protected from the direct action of flame by means of some non-conducting material. Intense heat will destroy the strength of wrought iron as well as that of cast, but it will stand an infinitely greater heat before it will yield. Plastered timber, so long as the plaster remains upon it, cannot be affected by ordinary fires, and is, practically, fire proof. Any means, therefore, by which a plaster composition could be attached to exposed parts of iron work, would be a great benefit in fire proof warehouse construction, and would make them in reality what they are only in name. If columns could be cased with a durable cement, leaving an air space between the column and casing, it would be an absolute impossibility for the iron column to become heated to destruction. In fact, it may be said, that no iron building is fire proof simply because it is of iron. The chances of fire are, of course, greatly lessened, but it can be destroyed by fire, and until a building can be made proof against *destruction* by fire, as well as *non-combustible*, we are far from perfection, in this class of buildings at all events.

In another number we propose to take up some of the more recent iron constructions of New York, illustrate some of their detail and connections, and make some comment upon the distribution of material. We believe that most all professional matter has been published to illustrate *good* practice. Finally, convinced that *bad* practice is as necessary to be recorded as good, we propose to contribute our mite on that side of the account. A chart, showing the deep water, is valuable and necessary to the navigator; but, by puttingupon it the rocks and shoals, we show him not only what to do, but what to avoid.

A. P. B.

Civil and Mechanical Engineering.

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

By G. S. Morison, C. E.

(Continued from page 164.)

For the arrangement in which the most economical division of panel is adopted,

$$c = b \frac{n}{m+n}$$

and the whole web is proportional to

$$\frac{(m+n)\,a^2 + \dfrac{m\,n}{m+n}\,b^2}{b}$$

which is a minimum when

$$\frac{m\,n}{m+n} - (m+n)\frac{a^2}{b^2} = o$$

$$b = a\frac{m+n}{\sqrt{m\,n}}$$

Table II.

Value of m ($n=1$)	Relative Material in Web.				Economical inclination of strut.
	1st arrangement. Ties vertical.	2d arrangement. Struts vertical.	3d arrangement. Ties and struts equally inclined.	4th arrangement. Most economical.	
4	$5\,a^2 + 4\,b^2$	$5\,a^2 + b^2$	$5\,a^2 + 1\frac{1}{4}\,b^2$	$5\,a^2 + \frac{4}{5}\,b^2$	$\frac{1}{5}\,b$
3	$4\,a^2 + 3\,b^2$	$4\,a^2 + b^2$	$4\,a^2 + b^2$	$4\,a^2 + \frac{3}{4}\,b^2$	$\frac{1}{4}\,b$
2	$3\,a^2 + 2\,b^2$	$3\,a^2 + b^2$	$3\,a^2 + \frac{3}{4}\,b^2$	$3\,a^2 + \frac{2}{3}\,b^2$	$\frac{1}{3}\,b$
1	$2\,a^2 + b^2$	$2\,a^2 + b^2$	$2\,a^2 + \frac{1}{2}\,b^2$	$2\,a^2 + \frac{1}{2}\,b^2$	$\frac{1}{2}\,b$
$\frac{1}{2}$	$1\frac{1}{2}\,a^2 + \frac{3}{4}\,b^2$	$1\frac{1}{2}\,c^2 + b^2$	$1\frac{1}{2}\,a^2 + \frac{3}{8}\,b^2$	$1\frac{1}{2}\,a^2 + \frac{1}{3}\,b^2$	$\frac{2}{3}\,b$
$\frac{1}{3}$	$1\frac{1}{3}\,a^2 + \frac{1}{3}\,b^2$	$1\frac{1}{3}\,a^2 + b^2$	$1\frac{1}{3}\,a^2 + \frac{1}{3}\,b^2$	$1\frac{1}{3}\,a^2 + \frac{1}{4}\,b^2$	$\frac{3}{4}\,b$
$\frac{1}{4}$	$1\frac{1}{4}\,a^2 + \frac{1}{4}\,b^2$	$1\frac{1}{4}\,a^2 + b^2$	$1\frac{1}{4}\,a^2 + \frac{5}{16}\,b^2$	$1\frac{1}{4}\,a^2 + \frac{1}{5}\,b^2$	$\frac{4}{5}\,b$

the web then being proportional to

$$2\,a\,\sqrt{mn}$$

When $m = n$, and the material of the web is equally capable of sustaining tension or compression, the third and fourth arrangements given above coincide, and the Warren Girder with braces inclined at an angle of 45° (the length of panel being twice the length of the truss), becomes the most economical form of web. For other cases, the relative economy of the four arrangements will appear from the tables. In Table II. a denotes the depth of truss, and b the length of panel as heretofore; in Table III. the most economical length of panel is adopted in each case, and the value of the web reduced in each case to decimals of the cost of a web of the most economical form.

TABLE III.

$\frac{m}{n}$	1st arrangement. Vertical ties.		2d arrangement. Vertical struts.		3d arrangement. Ties and struts equally inclined.		4th arrangement. Most economical.		
	Economical length of panel.	Material in web.	Economical length of panel.	Material in web.	Economical length of panel.	Material in web.	Inclination of strut.	Economical length of panel.	Material in web.
4	1·118 a	2·236	2·236 a	1·118	2 a	1·25	$\frac{1}{5}\,b$	2·5 a	1
3	1·155 a	2·	2 a	1·155	2 a	1·155	$\frac{1}{4}\,b$	2·309 a	1
2	1·225 a	1·732	1·732 a	1·225	2 a	1·061	$\frac{1}{3}\,b$	2·121 a	1
1	1·414 a	1·414	1·414 a	1·414	2 a	1·	$\frac{1}{2}\,b$	2 a	1
$\frac{1}{2}$	1·732 a	1·225	1·225 a	1·732	2 a	1·061	$\frac{2}{3}\,b$	2·121 a	1
$\frac{1}{3}$	2 a	1·155	1·155 a	2·	2 a	1·155	$\frac{3}{4}\,b$	2·309 a	1
$\frac{1}{4}$	2·236 a	1·118	1·118 a	2·236	2 a	1·25	$\frac{4}{5}\,b$	2·5 a	1

From these two tables, the following practical observations may be derived:

Between the limits $\frac{m}{n} = 3$ and $\frac{m}{n} = \frac{1}{3}$, the third arrangement (Warren Girder), is the most economical of the three forms of web in common use, while between the limits $\frac{m}{n} = 2$ and $\frac{m}{n} = \frac{1}{2}$ its cost

differs so little from the theoretical minimum that, allowance being made for the simplicity of its connections, it may practically be regarded as the most economical arrangement. It possesses the further advantage of giving a point of support in the centre of each panel, as the floor may be suspended by a light rod from the intersection of the strut and tie with the top chord. For structures entirely of wood or of iron, $\frac{m}{n}$ will always fall within the limits last given, and if in that case the connections of the middle panels be so made that the same bars are capable of acting both as struts and ties, no additional counter-bracing will be needed, and a very economical web will be the result.

The first arrangement (vertical ties), is the most economical of the three common forms, when $\frac{m}{n}$ is less than $\frac{1}{3}$. In composite structures in which wood is used for the struts and iron for ties, $\frac{m}{n}$ will often be less than $\frac{1}{2}$, and in certain localities where wood is cheap, and iron dear, may be less than $\frac{1}{3}$; hence the merit of this form of web for such structures, and it has the further advantage of being effectively counter-braced by the addition of counter struts alone, no additional ties being needed. The Howe truss, in which this arrangement is adopted, has become the standard form of wooden bridge, though as commonly constructed, with short panels, counter-braces carried from end to end, and useless vertical posts over the supports, this bridge is far from being the economical structure it is capable of being made.

The second arrangement (vertical struts), is the counterpart of the first, and is an economical form when $\frac{m}{n}$ exceeds 3. It is superior to the first arrangement in structures entirely of iron, because a greater section of strut than of tie is then needed, but it is inferior to the third arrangement in this case. In composite structures it is very much the most costly form of the three.

The economical length of panel is always greater than the depth of truss, and in many cases, double the depth. So great a length of panel is inconvenient from the distance it leaves between the available points of support; but the panels may be shortened materially, without greatly increasing the cost. Table IV. shows the relative cost of the web of the third arrangement for different lengths of panels. Table V. gives the same for the first arrangement when

$\frac{m}{n} = \frac{1}{2}$ or $\frac{1}{3}$, and for the second arrangement when $\frac{m}{n} = 2$ or 3, these cases being counterparts. It will be seen that after the length of panel is reduced to about half the economical length, the increase in cost becomes very rapid.

The material in the web depends upon the ratio between the length of panel and the depth of truss, and hence, if the inclination of the bars is left unaltered, the cost of the web is independent of the depth of the truss. This may appear anomalous, but it is to be remembered that though the length of the braces is increased, their number is diminished. In practice, however, the cost of the web will increase slightly with the depth, unless the struts are of such a form that the strength per unit of section is independent of the length.

TABLE IV.

Length of panel.	Angle of braces.	Relative material in web.
·5 *a*	75° 58′	2·125
·75 *a*	69° 27′	1·521
a	63° 26′	1·25
1·1 *a*	61° 11′	1·184
1·2 *a*	59° 2′	1·133
1·3 *a*	56° 59′	1·094
1·4 *a*	55°	1·064
1·5 *a*	53° 8′	1 042
1·6 *a*	51° 20′	1·025
1·7 *a*	49° 38′	1·013
1·8 *a*	48° 1′	1·006
1·9 *a*	46° 28′	1·001
2 *a*	45°	1·

In proportioning the several members of the web, the sections should of course correspond to the ordinates of the curves in Fig. 11. The following rule will often be found useful; though not

strictly accurate, the error is on the safe side. Make the centre braces capable of bearing one-eighth of the whole moving load ($\frac{1}{8}\,w'\,l$), and the end braces capable of sustaining one-half the entire load, and average the intermediate braces between those at the end and centre. The counter-braces may be proportioned in a similar way, graduating from the centre to the panel in which no counter is needed.

TABLE V.

Length of panel.	Relative material in web when $\frac{m}{n} = \frac{1}{2}$ (1st Ar.) or 2 (2d Ar.)	Relative material in web when $\frac{m}{n} = \frac{1}{3}$ (1st Ar.) or 3 (2d Ar.)
$\cdot 5\,a$	1·876	2·125
$\cdot 75\,a$	1·871	1·521
a	1·155	1·25
$1{\cdot}2\,a$	1·068	1·144
$1{\cdot}4\,a$	1·023	1·064
$1{\cdot}6\,a$	1·003	1·025
$1{\cdot}732\,a$	1·	....
$1{\cdot}8\,a$	1·001	1·005
$2\,a$	1·010	1·

(To be continued.)

BELTING FACTS AND FIGURES.

BY J. H. COOPER.

(Concluded from page 176.)

"IN such extreme cases of high speed belts, find the breadth of the first motion belt, by the formula for ordinary belting above (a), then if—

A = acting area of first motion belt.
v = velocity of first motion belt.
a = acting area of high speed belt.
V = velocity of high speed belt.

$$a = \frac{Av}{V}.$$

The acting area of either belt $= l \times b$, where l = length of circumference of driven pulley embraced by the belt,

b = breadth of the belt.

$\therefore b = \frac{a}{l}$ in the case of the high speed belt.

"If there is no first motion belt exclusively for the machine, it will be easy to suppose a hypothetical case from which the breadth of the high speed belt may be calculated."

15. From Haswell's *Engineer's Pocket-Book*, 1867 edition, we take the following: "A 4-horse engine transmits its power through a leather belt over a cast iron pulley 4 feet diameter, running one hundred revolutions per minute and embracing ·4 of its circumference.

"In this example the thickness of belt is taken at ·15 inch, and the strain at 210 pounds, which gives 4·67 inches for width of belt, and 122·26 square feet of belt per minute per horse-power, or 101·88 square feet, when ·5 of the circumference of pulley is embraced, using Morin's ratio of 2 : 2·4. If thickness of belt be taken at $\frac{3}{16}$ inch, and half the circumference be embraced by belt, then we have 81·375 square feet per minute per horse-power.

"An 11-inch belt on a 4-foot pulley running from 1200 to 2100 feet per minute will transmit the power of a double steam engine with 6-inch × 11-inch cylinders, 125 revolutions per minute, under a steam pressure of 60 pounds per square inch."

16. Fairbairn, in his treatise on "Mill Work," gives a table "for

determining the least width of straps for transmitting various amounts of work over different pulleys. The velocity of the belt is assumed to be between 25 and 30 feet per second, and the widths of the belts are given in inches. With greater velocities the breadth may be proportionably decreased."

The following formula will meet every requirement of the table:

$$W = \frac{5940 \text{ HP}}{1650\, d}.$$

In which W = width of belt in inches.
HP = horse-power.
d = diameter of smaller pulley in feet.
1650 = average speed in feet per minute,

from statement above, and which might be changed for v = velocity of belt in feet per minute to make the rule more general, which would seem to be allowed by the closing paragraph of the quotation.

The use of d in this formula forbids the naming of any definite area of belt running per horse-power per minute. If we take, however, the cases of belts from 12 inches to 24 inches wide on a 6-foot pulley, transmitting from 20 to 40 horse-power, and giving 82½ square feet of belt per minute per horse-power, we would not be stepping outside the line of usual good practice in selecting average examples from the table. But if we select from one extreme of the table a 1·4 inch belt running on a 10-foot pulley, transmitting 4 horse-power, or 48·125 square feet of belt per minute per horse-power, we will find it, if not out of the limits of possibility, certainly not within the ordinary economy of practice as to width of belt and diameter of the pulley. On the other extreme, the proportion of a 43·2-inch belt, running on a 12-inch pulley, and transmitting 12 horse-power, or measuring off 495 square feet of belt per minute per horse-power, is such an excessive one that perhaps it never has and certainly never should be used in practice.

Is it a subject of wonder, then, that we find in this work that belts are charged with "cumbrousness, the expense of their renewal and the necessity for frequent repairs," when from disproportion of pulleys and belts, such immense allowance of width must be made to gain the required adhesion?

17. From J. W. Nystrom's *Pocket-Book of Mechanics*, we take the following, in which—

b = breadth of leather belt in inches.
H = horse-power transmitted by belt.

v = velocity of belt in feet per sec.
d = diameter in inches. } of smaller pulley.
n = revolutions per minute. }
F = force in pounds transmitted by belt.
a = number of degrees of belt contact with smaller pulley.

$$v = \frac{d\,n}{230} \qquad b = \frac{7500\ \text{H}}{d\,a}.$$

$$\text{H} = \frac{v\,\text{F}}{550} \qquad b = \frac{13{\cdot}5\ v\,\text{F}}{d\,a}.$$

$$\text{H} = \frac{d\,n\,\text{F}}{126{,}500} \qquad b = \frac{n\,\text{F}}{18{\cdot}8}.$$

$$\text{F} = \frac{126{,}500\ \text{H}}{d\,n} \qquad b = \frac{29\ n\,\text{H}}{v\,a}.$$

18. "Having made practical use of the following table for several years with perfect satisfaction, I cheerfully recommend it to all who may at times be in want of reliable information with regard to belts."

We give an example from table which will fairly represent all therein.

A 6-inch belt, running 2200 feet per minute gives 12¼ horse-power, which = 89·8 square feet per minute per horse-power.—W. B. in *Sci. Amer.*, March 3, 1860, page 150.

19. "The belt that drives our establishment was originally 10 inches wide, but is now stretched to about 9 inches. It transmitted the full power of a 10-inch × 20-inch engine when working under 70 pounds of steam to the square inch. The driving side of the belt ran under a 36-inch iron pulley on the engine shaft, turning a 36-inch one on the line shaft, the slack side sagging 10 inches to 12 inches when at full work and it never slips."

"This belt has not been touched during the past three years, except to relace it, and has been running almost every day since it was started."—T. McG., Jr., in *Sci. Amer.*, March 24, 1860, p. 197.

20. "To find the power of a belt: The width in inches, multiplied by the velocity in feet per minute, divided by 1070, equals the power."

"Ex. $5 \times 2000 \div 1070 = 9{\cdot}345$ horse-power."

This rule gives 89·17 square feet per horse-power per minute.—D. E. C. in *Sci. Amer.*, March 24, 1860, p. 197.

21. "The following, by an eminent machinist, has been found to

answer perfectly for belting, and has been used by one having many years experience in constructing engines and mill work."

"It is calculated to give some 25 per cent. surplus power before material slippage of belt can occur."

$$W = \frac{H\,P\;5400}{V\,d}.$$

In which W = width of belt in inches.
H P = horse-power.
V = velocity of belt in feet per minute.
d = diameter of smaller pulley in feet.—
R. F. in *Sci. Amer.*, Sept., 1855, page 14.

22. An horizontal non-condensing engine, with a cylinder 12 inches diameter, 30 inches stroke, running 66 revolutions per minute, under 72 pounds of steam in boiler and an average pressure of 19·7 pounds of steam on piston, has a 13½-inch belt on an 8-foot fly-wheel pulley, which runs over a 4-foot pulley on a shaft 18 feet vertically above. Speed of belt 1658·58 feet per minute. On one occasion the indicator showed 21 horse-power transmitted, this would give 88·81 square feet of belt per horse-power per minute.

23. An engine similar to that above, with 10 inches × 24 inches, cylinder, making 80 revolutions per minute, under 100 pounds of steam in the boiler, and showing by the indicator a constant work of 33 horse-power, has a 11½-inch belt on a 5-foot pulley on engine shaft. This belt is crossed and runs over a 34-inch pulley on the "line" shaft 8 feet above and 18 feet distant. Number of square feet of belt transmitted per horse-power per minute 36·5. Speed of belt 1256 feet per minute.

24. An engine like example No. 22 has a cylinder 15 inches diameter, 36 inches stroke; fly-wheel pulley 12 feet diameter, carrying a 17½-inch belt, which passes over a 5-foot pulley, 6 feet above and 18 feet 6 inches distant; top fold of belt slack.

Engine makes 48 revolutions per minute under 65 pounds of steam, and by the indicator shows a work done of 40·7 horse-power. Speed of belt 1809·12 per minute, and square feet of belt transmitted 64·61 per horse-power per minute.

25. An horizontal non-condensing engine, with 11 inches × 30 inches cylinder, arranged with two steam and two exhaust valves of the double beat balanced Cornish style, each operated by a cam, the two former under the control of the governor. A 10-foot fly-wheel pulley carries a 20-inch belt. On the line shaft 6 feet above and

15 feet distant is a 5-foot pulley, the belt passes over this pulley, the top fold running slack. Under 80 pounds of steam in the boiler a pressure of 60½ pounds per square inch on the piston is maintained to the point of cut-off, which was one-third the stroke on one occasion when the indicator showed a work of 29·27 horse power; speed of engine 56 revolutions per minute. The load of this engine is very variable; the average of a number of cards taken show 25 horse-power. Speed of belt 2098·26 feet per minute, and number of square feet of belt per horse-power per minute transmitted 83·92.

26. A 20-inch × 48-inch cylinder horizontal non-condensing engine has a 16-foot fly-wheel pulley carrying a 24-inch belt, and runs about 50 revolutions per minute. This belt drives a 5 feet 4 inches pulley, 32 feet distant in an angle of about 40°, the top-fold slack. By the indicator the engine is working up to 150 horse-power. Speed of belt 2513 feet per minute, and square feet transmitteed per minute per horse-power equals 33·5.

27. An 18-inch × 36-inch engine, having a 14-foot 8-inch fly-wheel pulley, making 52 revolutions per minute, carries two belts; a 15-inch running over a 5-foot pulley directly above, 45 feet distant, and a 16-inch, running over a 6-foot pulley 20 feet distant, at an angle of about 30°.

This engine, under a boiler pressure of 85 pounds, shows by the indicator, 114·6 horse-power. Speed of belts 2392 feet per minute, and square feet of belt transmitted per minute per horse-power 54.

28. A 14-inch by 36-inch cylinder engine similar to No. 22 has a 12-foot fly-wheel pulley carrying an 18-inch belt, tight fold below at an angle of about 30°. Pulley on line shaft 6 feet diameter, and about 25 feet distant. Speed of engine 56 revolutions per minute. Horse-power by the indicator 49. Speed of belt 2111·2 feet per minute, and square feet per horse-power per minute 64·63.

Examples 12 and 22 to 28 inclusive, represent belting in constant use in this city—engines and machinery constructed by different parties.

The usual rating of engine in example 22 is 30 horse-power, which would give 62·17 square feet of belt per horse-power per minute.

Engine in example 23 is usually called a 20 horse, and at this estimate we should have 60·183 square feet of belt per horse-power

per minute. As now running the engine and belt are over-worked which is amply shown by the destructive wear of both.

Example 24 is doing very well, and may be considered a very good proportion, except shortness of belt, 8 or 10 feet more of which would increase adhesion and lessen friction.

Example 25 is a fair one, belt in use eight years, is in good condition, never slips and runs freely. The belt might be a little longer.

No.	Square feet of belt per horse-power per minute.		No.	Square feet of belt per horse-power per minute.	
	A.	B.		A.	B.
1	100·	....	18	89·80	89·80
2	66·666	66·666	20	89·17	89·17
3	100·	....	22	88·81	62·17
4	64·8	64·8	23	86·50	60·183
5	91·63	91·63	24	64·61	64·61
6	23·8	....	25	88·92	88 92
8	39·27	....	26	83·50	62·70
9	66·666	66·666	27	54.	77·24
"	69·44	69·44	28	64·63	79·15
10	75·	75·	A	75·	75·
11	125·	....	B	62·79	62·79
13	97·232	97·232	C	68 69	68·69
14	91·666	91·666	D	47·61	......
15	81·375	81·375	E	89·89	89·89

Column A gives an average of 72·873
" B " " 75·899

Example 26 is that of an over-worked engine and belt. That size cylinder should not do over 100 horse-power, where long continued service in good running order is desired, and owing to a faulty plan in arrangement of parts of engine, 80 horse-power

would be a sufficient load, at which latter rate we should have 62·7 square feet of belt per horse-power per minute.

Example 27 is that of another engine doing severe labor; at 80 horse-power, giving a belt area of 77·24 square feet per minute, this engine would run in every way much better, of which we have ample proof in the shape of several break-downs.

Example 28 has been running about 3½ years, gives great satisfaction, is called a 40 horse engine which would give a belt area of 79·15 square feet per horse-power per minute.

In column A of the above table is given consecutively the square feet of belt per horse-power per minute of the foregoing rules. Examples A, B, C, D and E are taken from the *Franklin Institute Journal* of January, 1868, page 24.

In column B are rejected all the results of 100 square feet and over and all under 50, which are either from assumed or *overworked* examples.

The extremes of practice seem to run from 33·5 to 100 which are worth noting, while 75 square feet per minute per horse-power seems a fair average of the best attested examples.

It is to be hoped that all who are in the line of practice with belts will contribute to our limited stock of published results of this all but universal method of transmitting power.

Philadelphia, August, 1868.

ACTION OF UNDER-CURRENTS IN THE MISSISSIPPI.

By James B. Eads, C. E.*

Examinations made by myself and other engineers, have revealed the fact that the bed-rock of the river, which is limestone, is overlaid with a deposit of sand about fifteen feet deep near this shore, and perhaps 100 feet at the other; the increase in depth being very regular as we proceed towards the Illinois shore. The borings, as far as made, indicate a regular slope of the rock from this shore, which has been traced as far as the location of the eastern channel pier, where it is about seventy-nine feet below the deposit. Near the Illinois shore, ninety feet of boring has failed to reach the rock. The sandy bed of the river in low water is nearly level.

* From Report on Illinois and St Louis Bridge.

Soundings made by me prove that this deposit is scoured out to a great depth in time of floods and freshets. Although I have not had any extreme stage of water in which to make my observations, I found that a rise thirteen feet less than high-water mark caused a scour of eighteen feet. The greatest variation in the height of the river known at this place is about forty-one feet. An average depth of about eight feet, with a width of 1,600 feet, represents the volume of the river at extreme low water at the location selected. Extreme high water covers an immense area of bottom lands above and opposite the city, and the construction of numerous railway dykes across these from East St. Louis, reduces the water-way at Washington avenue to about 2,200 feet in width at high-water mark. On this shore and on the other, this water-way is thoroughly revetted below the low-water line with rubble stone and protected by the wharf pavements above that line. The concentration into this narrow channel of the vast volumes that are sometimes poured out of the gigantic-net-work of streams above St. Louis, the main artery alone of which is navigable over a thousand leagues above this city, assures me that in time of floods it is not improbable that this deposit is removed to twice or thrice the depth shown by my soundings, and perhaps to the rock itself.

I had occasion to examine the bottom of the Mississippi, below Cairo, during the flood of 1851, and at sixty-five feet below the surface I found the bed of the river, for at least three feet in depth, a moving mass, and so unstable that, in endeavoring to find footing on it beneath the bell, my feet penetrated through it until I could feel, although standing erect, the sand rushing past my hands, driven by a current apparently as rapid as that at the surface. I could discover the sand in motion at least two feet below the surface of the bottom, and moving with a velocity diminishing in proportion to the depth at which I thrust my hands into it.

It is a fact well known to those who were engaged in navigating the Mississippi twelve years ago, that the cargo and engine of the steamboat America, sunk 100 miles below the mouth of the Ohio, was recovered, after being submerged twenty years, during which time an island was formed over it and a farm established upon it. Cotton-wood trees that grew upon the island attained such size that they were cut into cord-wood and supplied as fuel to the passing steamers. Two floods sufficed to move every vestige of the island, leaving the wreck of the America uncovered by sand, and forty feet

below low-water mark, where, in 1856, the property was recovered. Pilots are still navigating the river who saw this wreck lying near the Arkansas shore, with her main deck scarcely below low-water mark at the time she was lost. When the wreck was recovered the main channel of the Mississippi was over it, and the hull of the vessel had been cut down by the action of the current at the bottom, nearly forty feet below the level at which it first rested; and the shore had receded from it by the abrasion of the stream nearly half a mile.

These remarkable, but well attested facts, came under my own observation, and occurred at Plumb Point, one hundred miles below Cairo, where the Mississippi is more than one mile wide, and where the lateral action of the current is not confined as it is here by stone, and where the depth of the action of the under currents must be much less than at this narrow passage.

Singularly enough, the fact is almost certain that at seasons of *lowest* water, this deposit is also liable to be removed to an extent probably sufficient to lay bare the rock in mid-channel. The current being much less when the water is low, the sand accumulates to its greatest depth. When the river freezes over, which only occurs when it is quite low, a strong crust of ice, from ten to fifteen inches thick, is formed in this narrow gorge, while there are frequently great stretches of the river above unclosed. The floating ice formed in these open spaces is carried down in large masses, which accumulate in this and other narrow passages of the river, and form what are termed ice gorges. These accumulations sometimes extend several miles above the contracted channels of the river, and cause the water to rise, or in river parlance, "back up," ten and even twenty feet in some instances, above its former level. The firmly frozen crust serves to hold the masses that are accumulated beneath it, and the great height attained by the "backing up" of the water above the gorge increases the currents that are sweeping below the ice to a degree probably greatly exceeding that of the floods, if we may take the water levels above the gorge as an index to the current created by this hydrostatic pressure. These currents, I believe, would prove too great to be resisted by any ordinary rip-rap (or loose stone) usually used to protect foundations not resting on the rock. The ice being lighter than the water, it follows that these currents will be constantly acting beneath the gorged ice, and in direct contact with the sand. As rapidly as the latter is cut away,

fresh supplies of ice are driven under, and thus the mass continues to grow in depth, and the current to be directed nearer to the rock. After a few weeks the pressure of the back-water becomes so enormous as to sweep the gorge away, and on such occasions the open space of water below the gorge is at once filled for miles with the submerged ice thus liberated. This ice can readily be distinguished from the crust or surface ice by its scarcely floating, and by the quantities of sand and mud with which it has been saturated during its imprisonment.

On two occasions, I undertook to cut a channel in the ice through which to remove from gorges two valuable diving-bell boats to places of safety. The undertaking was only successful in one case. The surface ice being removed from the canal and hauled off on its sides, I found the quantity of submerged ice which continually arose, when that in sight was removed, was so great that the supply seemed inexhaustible. In the case where I was successful, I was able to cut the channel from an open part of the river up to the vessel, and through it the submerged ice was floated out and the channel thus cleared.

In the winter of 1855, the steamer Garden City, of about 800 tons burden, was inclosed in the ice gorge which formed in this harbor. Many of our citizens will remember that a partial movement of the gorge caused her sides to be crushed, in consequence of which the vessel filled with water. She was lying at the upper part of the city in front of a large stone quarry, the debris from which had been for several years thrown into the river by the quarry-men, and had formed a steep, rugged shore of such slope as the broken stone naturally assumed. The water where the vessel sunk was twenty-five feet deep, but she was sustained upon the gorged ice beneath her, so that her deck was scarcely under the surface. She was in this condition when I was called upon to save her. Her hull being about nine feet in depth, it is evident that the ice which sustained her must have been packed to the bottom, and sixteen feet deep. This ice supported her with her engines and boilers, and a cabin over them about 150 feet long, until the bank was removed, ways placed on the ice under the steamer, powerful purchases secured ashore, and the vessel hauled broadside in to, and upon the bank in safety, before the gorge gave way. The time occupied in doing this was about ten days, nearly all which time the steamer

was resting on ice that had been driven under the surface by the action of the current.

The establishment of piers in the channel of the river must facilitate the formation of an ice gorge at the bridge in the winter, and they will certainly tend to its retention until the sand is scoured out about and between them to an unknown depth.

For these reasons I have maintained and urged that there is no safety short of resting the piers for your bridge firmly upon the rock itself. On no other question involved in its construction does my jüdgment more fully assure me that I am correct, although the Convention of Engineers assembled here last summer announced in their report that they did not consider it essential to go to the rock with all the channel piers of Mr. Boomer's bridge. The Convention assumed that the greatest possible scour would not exceed thirty feet below low-water mark (equivalent to the removal of twenty-two feet of deposit. See Report, page 80.) I am supported in my opinion upon this matter by many eminent engineers with whom I have exchanged views upon the subject.

The recent destruction of many of the bridges in British India, by having their foundations undermined by the action of floods upon the sandy bottoms of the streams in that country, furnishes a warning that we should not neglect.

PROPOSED METHOD OF SINKING THE PIERS FOR THE ST. LOUIS BRIDGE.

By James B. Eads, C. E.*

A number of designs and estimates were made by me to determine the most practicable, economical and reliable method of constructing the parts of the channel piers below low-water mark. These designs and estimates included the use of cast iron cylinders, of diameters varying in the different plans from three to fifteen feet, which were to be sunk to the rock and filled with concrete. The danger of scour, and the difficulty of binding these cylinders together beneath the surface of the sand, so as to insure stability under the strains produced by the thrust of the arches, induced me to increase their diameters in subsequent designs, until they became so great that wrought iron was substituted, and finally two cylin-

* From Report on Illinois and St. Louis Bridge.

ders, each of a diameter equal to the width of the pier, were tried with smaller ones about them, to complete the entire dimensions of the foundation. The same difficulty of binding these together in a manner to insure safety to the superincumbent masonry, in the event of deep scour, as well as to give promise of any great durability, still remained.

Cast iron cylinders may be used with great advantage in forming subaqueous foundations in situations where there is no scour, but the dangers to be guarded against in this location would render them, I think, less reliable and more expensive than other methods.

My experience of the effects of fresh water upon wrought and cast iron, submerged for many years in the Mississippi, assures me that the latter can be relied upon as almost indestructible, but that wrought iron will oxidize or rust out so rapidly that in twenty years the strength of a bolt an inch and a half in diameter would probably be reduced one-half. To bind these cylinders together, beneath the sand, would greatly increase the cost of adopting them, and to use wrought iron to secure them above the sand would fail to insure durability. To undertake to do it with cast iron would be more expensive, and the slightest unequal settlement of the different ones composing the mass would be likely to fracture a material so brittle. To sink these cylinders, either by the pneumatic process, or by any of the methods known, to the requisite depth, would be exceedingly expensive. The great quantity of iron required in them, and the fact that they must be filled with masonry, would render a foundation of the necessary dimensions, if composed of them, much more expensive than if made of stone alone.

Having arrived at this point in the solution of the most important problem connected with the design and erection of your bridge, I determined to construct the base of the pier entirely of solid masonry, within a water-tight floating coffer-dam, whose sides should be extended above water from time to time, as it sunk deeper and deeper, with its increasing burden of stone and cement.

Piers of smaller dimensions have been constructed in a similar manner, and placed upon foundations favorable to their permanent reception. When sand or mud has been interposed, and its removal rendered necessary, the sides of the floating vessel have been extended downward below its bottom, to form a chamber or kind of diving-bell beneath the masonry. Through the masonry tubes were provided, by which workmen and materials could descend into the

chamber, and through these tubes air was forced to expel the water from the chamber, and enable the workmen to remove the sand or mud beneath the pier. These tubes required to have two or more air-locks or valves in them, that were closed behind the workmen or materials in their passage, to prevent the escapement of the compressed air in the chamber. This, of course, retarded the rapid progress of the work. To facilitate the excavation of the deposit an extra tube was introduced in the middle of the pier, and extended to the level of the bottom of the air chamber. The water stood within this tube at the level of the surface of the river, and through it an endless chain, carrying scoops or excavators, was made to rotate around a pulley at the bottom of the tube, and another at the top. In this way the sand was rapidly excavated without permitting the escapement of air from the chamber, and without passing the deposit up through the air-locks. The workmen in the chamber were enabled to shovel it to the bottom of the tube, where it was taken by the excavator, and discharged in vessels above.

The gradual descent of the pier was managed by screws, supported upon false works, erected around and over the site of the pier. As the sand was removed below, the pier was allowed to settle by slacking the screws, as it was only partially water-borne. When it had passed through a considerable depth of sand, the friction of the latter upon the sides of the pier held it to such a degree as to take all the strain off the screws, and when it moved downward, it was sometimes so suddenly that the supports were strained severely.

The shortness of the season in which each one of the piers for this bridge must be put in position, because of the floods of summer and the ice of winter, and the great amount of deposit to be removed, renders the pneumatic process just described too slow for this case, as well as too expensive. For the safety of the workmen beneath the pier, it is absolutely necessary to regulate its descent by screws or similar means, and to do this with piers of such magnitude would not be advisable.

The removal of the sand will be accomplished by sinking an elliptical-shaped caisson or curb of plate-iron through the deposit to the rock. This caisson will be open at top and bottom, and will be strongly braced on the inside with heavy angle irons placed horizontally around it. It will be larger at bottom than top, to facilitate its passage through the sand and relieve it of the friction. The

caisson will be suspended by false works erected around the site of the pier, and will be regulated in its descent by screws supported on the false works. As it is lowered into the sand, that which is inclosed by it will be excavated by steam machinery, until the caisson is finally sunk to the rock. It is not intended at any time to remove the water within the caisson, but only the sand it encloses; the object of the caisson being only to exclude the sand outside of it until that which it encloses has been removed, the rock leveled off with concrete, the floating coffer-dam placed in position within the caisson, and the pier so far built up in the latter as to sink it down to the concrete bed prepared for it.

The bottom of the coffer-dam will be formed of squared timbers, thoroughly caulked, and will be about two feet in thickness. Its sides will also be of timber, and so constructed as to admit of being disengaged from the bottom when the latter has reached the bed formed to receive it. The interior of the coffer-dam will be larger than the pier, and the latter will be constructed with certain cavities in it to be filled with masonry after the pier reaches the bottom, so that the weight of the pier will bear such proportion to the displacement of water as to insure the top of the masonry being kept but little below the surface of the river while the pier is being built within it. This will enable the sides of the vessel to be thoroughly braced against the pier, so as to resist the pressure of the water.

It is known that timber is indestructible when completely submerged in fresh water, Piles placed in the Rhine by the Romans, nearly 2,000 years ago, have been found to be entirely sound when removed within the present century. There are many other similar instances on record establishing the fact of its durability, whilst the soundness of the timber found in the bogs of Ireland and elsewhere indicates that it is unlimited by time.

When the bed rock has been prepared to receive the pier, the coffer-dam will be floated within the caisson, and will be guided by the latter as it descends with its load. It will be understood that the pier is completely water-borne by the coffer-dam until the quantity of masonry in it has become so great as to cause the dam to touch the bed on which its bottom, with the pier, is to rest permanently. When the pier has been completed above water, the dam is permitted to fill, and its sides will then be disengaged from the bottom and removed, to be used in putting down the next pier.

The caisson for the smaller pier can be withdrawn and used for the other one; and the larger one may possibly be saved also.

As before stated, the floating coffer-dam is not an untried experiment, but has been frequently used to place piers in position where the bed-rock or other substratum was favorable for their reception. The caisson has also been frequently used to exclude the sand or mud, and enable that within it to be removed sufficiently to facilitate the driving of piles to a greater depth and in firmer soil than would be otherwise practicable.

The estimates made for the cost of this work prove that it will be much less expensive than any other method yet devised; while the superiority of the foundations thus made will be beyond all question.

The Theory of Puddling.—In a paper read before the late meeting of the British Association by Mr. C. W. Siemens, on the subject indicated above, a new and important view was expressed as regards the nature of the process in question.

As is well known, it has been generally assumed that the cast iron on the hearth of the reverberatory furnace combined with oxygen from the heated air mingled with the burning gases which played upon it, and that the impurities, such as silicon and carbon, were thus removed from the iron, the first in the form of gas, the latter as solid silica, which, combined with the oxide of iron or fettling, introduced and formed a slag.

According to Mr. Siemens' experiments, however, it is from the fettling, and not from the air, that the oxygen is derived, by which the impurities suffer conversion, and the only effect of the air in the flame is to burn or oxydize the iron. This was proved by employing a perfectly neutral flame (one with no excess of oxygen), when it was found that not only did the process advance as well as before, but that the weight of wrought iron produced was fully equal to that of the pig employed. Now as some part of the pig—*i. e.*, the impurities, was undoubtedly removed, we see that some of the fettling must have been reduced, which clearly supports the new and is opposed to the old theory.

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

BY PROF. ALFRED M. MAYER, PH.D.

(Continued from page 186).

The Molecular Constitution of Matter.—The Atomic Theory of Boscovich.

OF the foregoing facts which we have brought together, concerning the general properties of matter and the effects of attraction and repulsion existing between the minute parts of bodies, we can frame a hypothetical theory which, in a few lines, or postulates, will embrace what we otherwise could not express in many pages.

This theory together with the doctrine of the Conservation of Energy, are the two most important generalizations in Physics, and, in our opinion, the following generalization forms an absolutely essential introduction to the proper study of this department of science.

The ancient Greek philosopher, Democritus, propounded an hypothesis of the constitution of matter, and gave the name of atoms to the ultimate unalterable parts of which he imagined all bodies to be constructed. In the 17th century, Gassendi revived this hypothesis, and attempted to develope it, while Newton used it with marked success in his reasonings on physical phenomena; but the first who formed a body of doctrine which would embrace all known facts in the constitution of matter, was Roger Joseph Boscovich, of Italy, who published at Vienna, in 1759, a most important and ingenious work, styled *Theoria Philosophiæ Naturalis ad unicam legem virium, in Natura existentium redacta.* This is one of the most profound contributions ever made to science; filled with curious and important information, and is well worthy of the attentive perusal of the modern student. In more recent days, the theory of Boscovich has received further confirmation and extension in the researches of Dalton, Joule, Thomson, Faraday, Tyndall and others.

We present here a generalization which, while giving the sub-

stance of the important postulates of Boscovich embraces others made necessary by the progress of science since 1760.

1. Matter has trilineal extension.
2. Is impenetrable.
3. Does not form a plenum.
4. All matter consists of indefinitely small but finite parts; of extreme hardness; indivisible, and unalterable by either mechanical or chemical means; and endued with impenetrability and inertia. These ultimate parts are called *Atoms.*
5. These atoms are not in mathematical contact, but are separated from each other by distances which are great when compared with the size of the atoms.
6. A union of atoms forms a molecule, and combinations of molecules form particles of which all bodies are composed.
7. There exist between the atoms, attractions and repulsions: when these tendencies are equal, the atoms preserve fixed positions and the volume of the body is constant. These molecular forces vary both in intensity and direction, by a change of distance, so that at one distance two atoms attract each other, and at another they repel; there being, within the distance in which *physical* contact is observed (about $\frac{1}{2000}$th inch), several alternations of attraction and repulsion.
8. The repulsion of two atoms generally diminishes more rapidly than their attraction when the distance between them is increased; while their repulsion increases more rapidly than their attraction when their distance is diminished.
9. The law of variation is the same in all atoms. It is therefore mutual; for the distance of *a* from *b* being the same as that of *b* from *a*, if *a* attract or repel *b*, *b* must attract or repel *a* with exactly the same force.
10. At all sensible distances (*i. e.* beyond $\frac{1}{2000}$th inch), this mutual tendency is attraction, and varies inversely as the squares of the distances. It is known as *gravitation.*
11. The last force which is exerted between two atoms as their distance diminishes, is an insuperable repulsion, so that no force however great can press two atoms into mathematical contact.
12. Between the molecules of *gases* continued repulsion seems to exist, so that when relieved of exterior force, a gas expands indefinitely.

Between the molecules of *liquids* exist attraction and repulsion,

Fig. 2

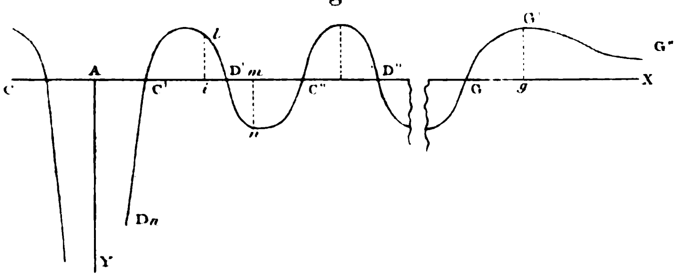


Fig. 3.

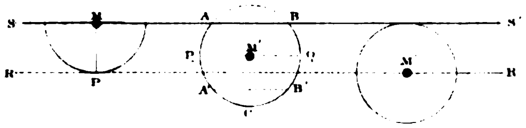
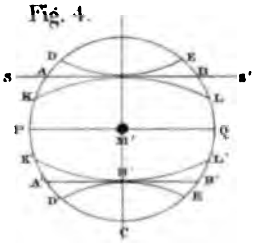
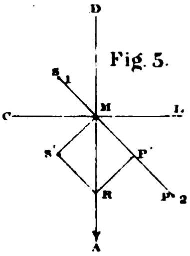
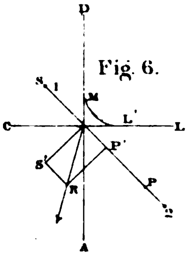


Fig. 4.







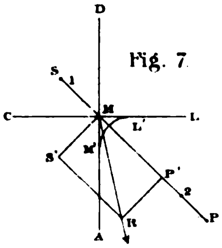
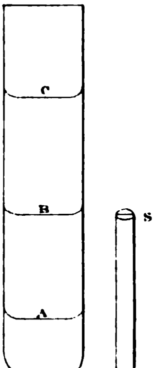


Fig. 8.



which maintain them at determinate distances; but they have no fixed axial direction, so that a liquid molecule will rotate around any imaginary axis on the action of the slightest force. Thus liquids have *fluidity*, while at the same time they have a small range of compressibility.

In *solids* the molecules have, besides their mutual attractions and repulsions, *polarity* or fixity of position of their axes *inter se*, so that when a molecule in any solid is turned around any axis, it will return to its primitive position after a series of decreasing oscillations.

Those of the above postulates which refer to the mutual action of atoms, can be geometrically expressed by means of an exponential curve. See Plate IV., Fig. 2.

Let an atom be at A, while another is anywhere on the line AX. Suppose that when placed at i for example, that an attraction exists between the atoms. The intensity of this attraction is represented by the length of the line $i\,l$, and we show that mutual attraction exists by drawing the ordinate to the point i *above* the axis AX. If the atom be supposed at m and repelled by A, then the repulsion and its intensity are expressed by drawing the ordinate to the point m, below the axis AX. This may be supposed to be done for every point of the length AG, which represents the distance between the glass plates in Huyghens' experiment, or about the $\frac{1}{2000}$ inch, and thus we will form an exponential curve.

As there are several alternations of attractions and repulsions, the curve will consist of various inflections lying alternately above and below AX. The last inflection, most distant from A, viz: G′ G″ is of such a form that the lengths of its ordinates being the reciprocals of the squares of their distances from A, it expresses the law of gravitation; the atom at G being at the point called the *limit of gravitation*, or about $\frac{1}{2000}$ inch from A. AX will be an asymptote to this curve, while the inflection C′ Dn will have AY for asymptote; for the ordinate expressing repulsion increases beyond all limit when the distance from A is just vanishing. The intermediate branches of the curve must be determined by means of the alternations of attraction and repulsion, in the experiments already described and by the aid of the various phenomena of capillarity and of molecular physics.

If an atom, supposed at the point C′, or C″, or &c., have its distance increased from A, it will, being under the curve, be attracted with an intensity represented by its ordinate. When set free it will

move with an increasing velocity towards its primitive position of equilibrium, which it will surpass on account of its inertia, and, coming into the sphere of repulsion, it will be repelled from A, and thus oscillate about its point of equilibrium. The atom will therefore eventually return to C′, or C″, or &c. These positions are called *limits of cohesion*, C′ being designated as the *last limit of cohesion.*

If an atom at D′, or D″, or &c., be moved ever so little from its position, it will rush to an adjacent limit of cohesion, either to the right or to the left, according as it was moved from or towards A. These points, D′, D″ &c., are called *limits of dissolution*, and differ from the limits of cohesion in being positions of unstable equilibrium, and therefore only a *temporary molecule* can be formed by an atom placed at D′, D″, &c., with an atom at A; while an atom at C′, C″, &c., together with the atom A forms a *permanent molecule*, which resists compression and dilatation, and whose component atoms return to their primitive positions when the extraneous force is removed; provided the compression or dilatation has not been too great; for, in that case, the atom C″, for example, might be forced beyond D′ by a compression, or removed beyond D″ by a dilatation, and would then rush to another position of permanent equilibrium, either to C′ or to G. The only molecule that cannot possibly be changed by compression is AC′. When, however, the amount of compression or dilatation of a body formed of permanent molecules is a very small fraction of its volume, the body regains the dimension it had before the compression or dilatation was applied, and it is found that the compression or dilatation is proportional to the force employed; for, in this case, the small portion of the curve which expresses the variation of repulsion or attraction may be considered a straight line, and therefore its ordinates are as its abscissas.

These logical consequences of the theory are confirmed by the most extensive experience. "Mr. Coulomb was engaged (for a particular purpose), in a series of experiments on the oscillations of springs, particularly of twisted wires. He suspended a nicely turned ball or cylinder by a wire of a certain length, and fitted it with an index, which pointed out the degrees of the torsion. He found that when a wire of twenty inches long was twisted ten times, the index returned to its primitive position, if repeated a thousand times, and the oscillations were made in equal times, whether wide or narrow.

But if it was twisted eleven times, the index did not return to its first place, but wanted nearly a whole turn of it. Here, then, the parts of the wire had taken new relative positions, in which they were again at rest. But what was most remarkable in Coulomb's experiments was this: He found that after the wire had taken this set (as it is termed by the artizans), it exhibited the same elasticity as before. It allowed a torsion of ten turns, and when let go, it returned, and after its oscillations were finished, it rested in the position from which it had been taken. I was much struck with this experiment, and immediately repeated it on a great variety of substances with the same result. The most inelastic substance that I know is soft clay. I got a thread made of fine clay at a pottery, by forcing it through a syringe. It was about $\frac{1}{12}$th of an inch in diameter, and eleven feet long. While quite soft (and smeared with olive oil, to prevent its stiffening by the evaporation of its moisture), I fastened it to the ceiling, and fixed a small weight and an index to its lower end. I found that it made 5½ turns a hundred times and more, without the smallest diminution of its elasticity, always recovering its first position. But when I gave it 7 turns it returned only 5½. Thus it took a set. In this new arrangement of its parts, I found that it again bore a twist of 5½ tnrns without taking any new set. And I repeated this several times. I then gave it 10 turns, in the same direction with the first seven. It returned 5½ as before, and was again perfectly elastic within this limit."

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"Another appearance of tangible matter shows a most encouraging conformity to the theory. Where bodies are very moderately compressed or dilated, the forces employed are proportional to the change of distance between the particles. This appears most exactly true in the experiments of Dr. Hooke, on which he founded his theory of springs, expressed in the phrase *ut tensio sic vis*, and his noble improvement of pocket watches by applying a spiral spring to the axis of the balance, which, by its bending and unbending, produced a force proportional to the angle of the oscillations, and therefore made them isochronous, whether wide or narrow. It is also confirmed by the experiments of Coulomb on twisted wires, and by the form of the elastic curve, as determined by Bemouilli, on the supposition that the forces with which the particles attracted and repelled each other, are proportional to their removal from their

natural quiescent positions. But it is found that when the compression or dilatation is too much increased, the resistance does not increase so fast; that it comes to a maximum by still increasing the strain, then decreases, and the body takes a great set or breaks. All this is perfectly analogous to the forces expressed by the ordinates of our exponential curve. In the immediate vicinity of the limits of cohesion, the ordinates increase nearly in the ratio of the abscissæ, then they increase more slowly, come to a maximum, decrease again, till we come to a limit of dissolution."

(To be continued.)

CORNISH PUMPING ENGINES

By W. H. G. West, First Asst. Eng., U. S. Navy.

In the July number of the *Journal of the Franklin Institute*, I find a paper upon this subject, from W. H. Henderson, Esq., Hydraulic Engineer, apparently intended to show the causes of the superiority of this kind of engine, but, in reality, to a careful reader proving, according to the author, that the rotative engine is equally good, or perhaps better.

In disposing of "the classified points of merit," he says (page 31), "Up to the point of cut-off the velocity of the weight is uniformly accelerated." This, Mr. H. here says, is an advantage; but on page 32 we find "a uniform speed of piston is required in the latter" pumping water.

The motion of the piston is accelerated until it has reached such a distance beyond the point at which the steam is reduced to the mean pressure as may be due to the energy stored up in the moving parts.

If in the Cornish Engine "the momentum acquired together with the force given out by the expanding steam, carries the piston to the end of its stroke," does not the *vis viva* or potential energy stored up in the moving parts of the rotative engine, together with the work done by the expanding steam, carry the piston of that engine to the end of its stroke, and does not the *steam* perform the *whole* work in either case?

The Cornish Engine passes through the steam stroke very rapidly. If the pressure at the end of the stroke equaled the resistance (page 31), the *vis viva* of the moving parts would shoot the piston through the cylinder-head, unless prevented by the

catches. Mr. H. gives us this same thing as a fault in the numerous direct-acting steam pumps (page 34), and in these words: "The terminal pressure must invariably be equal to the full load, or the pump will come to a dead stand." Now, why will not *momentum* help this unfortunate engine as well as the Cornish Engine? It will. Mr. H. knows it, and is convinced, too, that the terminal pressure need be no more equal to the full load in one machine than another, except where we have light moving parts, which, Mr. H. says, are bad for Cornish Engines (page 33), but good in any other engine (page 32).

On page 31, we find that the plunger descends with a "uniformly augmented velocity," and the momentum acquired is again stored up at the end of the stroke. The piston, and, therefore, the plunger, can *not* descend in this manner, for it is brought up by cushioned steam, just as that of the rotative engine is, and the velocity of each piston varies from full speed to a stand-still at each end. Where is the difference, and what ill effect would it have upon the engine, if Mr. Henderson's statement *were* correct? The fly-wheel would give back all the momentum or *vis viva* imparted to it, but the steam would not, in any engine.

Will Mr. H. call to mind that we find, in general practice, much higher steam used in rotative engines than in the Cornish, and will he favor us with an estimate of the amount of power, in steam, lost by this variable speed in any engine? None, I think. Two or three places in Mr. H.'s paper have been referred to where accelerated motion is described as a virtue.

In good rotative pumping engines the pump-rod is, and should be, attached to the piston-rod. Here we need but a light fly-wheel, heavy enough to overcome friction: for, though the steam is doing no work at the end of the stroke, there is no work to be done but that of overcoming friction.

No serious evil effects can result from increasing the speed of the plunger near the middle and towards the end of the stroke, for when the water is put in motion the plunger may move faster. Were the steam shut off, the *vis viva* of the moving water would carry the engine some distance with it, and the speed may, therefore, increase without loss, keeping the pressure against the plunger uniform. There is no loss here from variation of speed, except by friction; frictional resistance varies as the square of the speed, at low speeds, but as a higher power at higher velocities; and as the

Cornish Engine comes in like a rocket when it takes steam, we may infer that it is the least economical of engines, as far as that *serious quality* is concerned.

"We now pass to the saving of steam from loss by clearance and steam passages, and the isolation of the working-end of the steam cylinder from the cooling influence of the condenser." Isolation, in this case, means a "high degree of expansion," or very high temperature to very low temperature during the in-door stroke; then this low temperature—very little above that of the condenser—both sides of the piston during the out-door stroke; then exposure of all the cylinder but about a foot of the out-door end to this same temperature; and last, the exposure on the lower side during the in-door stroke to "the cooling influence of the condenser." That is saving by isolation with a vengeance. It is very well known that the pistons of Cornish Engines, perfectly tight at one end, leak badly at the other, when the cylinder has no casing, or when the casing is cold. This may well be expected from the difference of expansion of metal, and more especially in large Cornish Engines, where the grade of expansion is very high, and the corresponding differences of temperature are very great.

Cushion, in the rotative engine, means that the exhaust-valve closes just before the piston reaches the end of its stroke, and, shutting in a small quantity of the back-pressure steam, forms a cushion, which takes up the work remaining stored up in the moving parts. This, minus loss by condensation, is given out again immediately after the crank passes the centre.

Cushion, in the Cornish Engine, means shutting up steam, perhaps two pounds higher than that in the condenser, and compressing it to the same final pressure for the same size, weight and speed of engine, with the same degree of expansion. The operation, as well as the result, is the same in each case, and the only difference I can see is, that the valve is in one instance called the equilibrium, and, in the other, the exhaust.

On page 33, we have the following: "It is evident that by means of this cushioning, the loss from clearance and steam-ports is practically nothing, if the steam so compressed be equal to the *initial* pressure." How the extraordinary feat of forcing the piston up against the initial pressure is done by a simple weight, sufficient only to overcome the friction at a speed of about one hundred and fifty feet per minute, Mr. H. does not explain. It is more difficult

to comprehend than getting into a tub and lifting ones self by the handles; and even were it possible, the piston must instantly shoot back again, and we should have much of the water pumped out for nothing.

In the large rotative engine, a half inch is the usual clearance, and this cannot be afterwards changed. In the Cornish Engine, it depends entirely upon the cushioning; it may be changed by turning a small nut, and is changed by every rise and fall of steam. The stroke and power are also changed by every change of pressure, and as these changes become more considerable, the losses are increased.

Numbers of rotative pumping engines have poppet valves, and these valves are fitted so close to the inside of the cylinder that the piston passes within a half-inch of each valve-seat. There never has been a Cornish Engine built with such short ports.

The faithful return of *vis viva* is a very pretty fancy, but it does not apply to the Cornish Engine where it will not apply to the rotative.

Steam is not perfectly elastic; it condenses in expanding; it is condensed by radiation, and it cannot, therefore, return the *vis viva* imparted to it by the moving parts. There must be a loss, and the heavier the engine is, the greater will be that loss.

The advantage which the beam engine appears to have over the Bull engine is, that it *starts* its load with more ease. The Bull engine is generally more rigid than the beam engine, and in it we have a dead pressure from the beginning of the stroke; but the beam engine will have passed through some space, and will have given a velocity and an energy to the moving parts before the whole strain or weight of water comes upon the machinery; we then have two forces to start the load instead of one. But this advantage is so small that Bull engines do just as good duty as others—perhaps better; and one engine can be made to spring as much as another, if, at some risk, we make them weak enough.

The momentum (improperly called) of the piston and connections is given out gradually in the rotative engine, as the piston approaches the "dead point," and just before it reaches that point, momentum *vis viva*, or whichever is the correct word in this place, dies too, for here motion of the piston, &c., ceases, and without that, where is the energy? So not the smallest imaginable quantity is given

out through the crank-pin to the wheel, or anything else, at the "dead point."

Steam jackets may be applied to any engines, even to locomotives, and would be, too, if practical men thought it would pay. Numbers of marine and stationary engines have them. The Cornish Engine does not possess the sole right to wear jackets, any more than the rotative engine, only, enjoys the right of wearing its warm felt coat. The coal would do much better duty were the hot gases from it turned into the jacket, instead of being employed in evaporating water, half of which is condensed again before the remainder reaches the jacket.

The real causes of success of the Cornish Pumping Engine are so simple, that only men of very practical minds discover and appreciate them, and this simple machine remains a mystery even to those who have made its manufacture their principal occupation, when it is no more difficult to understand than is drawing water from a well in "the old oaken bucket."

Many rotative engines do as good duty as the best Cornish Engines, and the pump-work should be constructed on the same principle for all kinds; but many a man undertakes to design engines before he can sketch a windlass properly.

The simplest and cheapest way to pump water is, to force some perfectly smooth substance, without appreciable pores, into the body of water, so that the water may rise a corresponding amount and flow away. Here we have no friction, no leaks, and, therefore, no loss of efficiency. All the power is utilized. When we add a casing or working barrel with packing, we add friction; when we add valves, we add the work of forcing them open; when we add receiving and delivery pipes, we add friction; when we add turns, we add obstructions; when we contract the pipes or valves, we add thousands of smaller obstructions, and increase the friction, as the square of the speed of the water through the pipes must increase; and when the valves are lifted, they take time to get down again, and water must leak back. The valves and packing will leak at other times, unless they are carefully attended to.

In "Smith's Mechanics" I find the following statement: a pipe of 12 inches diameter, 2,340 fathoms in length, with a head of 20 feet, discharged $\frac{1}{18}$th of that which would have been obtained from a simple orifice of the same diameter. Cornish pumps, well designed, have large pipes; the length is governed by the depth of mine.

Plungers have been packed so tight as to heat the metal and vaporize the water around it. The receiving valve could not lift, and the pump did not work. Cornish pumps are packed with soft, elastic hemp packing, or the best substitute at hand, and the cup of the gland is kept full of some fluid lubricating matter.

The valves or clacks of the Cornish pumps are made of large diameter and small lift; they shut quickly, and the leak back through them is correspondingly small. The stroke of the plunger is always long, and the times of leaking back are thereby lessened.

There is but one turn in the Cornish pumps—that from the plunger-case to the column. The difference of velocity before and after impinging will be a measure of the loss. A 600-pounder cannon shot will pierce a 10-inch wrought-iron plate; but in about a foot, the velocity is reduced from about 1,800 feet per second to no speed at all. Were it fired along the face of the plate, it would be retarded only by friction and air, and would go five or six miles. One foot to five miles, and all owing to obstructions. Water, moving through pipes, acts in exactly the same way.

The above reasons, together with the fact that the attendants are guided by them in taking care of the machinery, explain the superiority of the *Cornish Pumps.*

There is nothing peculiar in the Cornish boiler, but it is put into its place with the knowledge that there is a certain amount of heat to be developed by the perfect combustion of the coal, and with the determination to utilize as much as possible of it. The grate-surface is large, the fire burns slowly, the gases have time to generate and mix with oxygen, and the combustion is almost perfect. In this way, for the same heat developed, a smaller amount of coal is burned than in ordinary furnaces. The boiler is completely enveloped in flues, the heating-surface is correspondingly great, and all the heat is absorbed by the water, except what is necessary for draft, or the little that is conducted away by the thick brick walls. These walls are very cool outside, and the draft is only sufficient to burn the coals slowly, so there is little or no heat lost.

The size of the boiler is regulated by the fact that a steam engine is to be driven—not a hydraulic jack. Water has a free passage to the hot plates, and steam has an equally free passage away from them and straight up through the water; not, as is very often the case in other boilers, along the faces of the hot sheets, keeping the water away. Then the boiler is made large enough for the engine;

there is no violent rush of steam, carrying water with it, into the cylinder at one time and perfect exhaustion at another. Everything is quiet, calm, regular; the steam is dry, somewhat superheated by the upper flues, and passes unobstructed, without any sound, through a large, short pipe to the engine; and these are the causes of economy in the *Cornish boiler.*

A large valve, with small lift, opens quickly, and the full boiler pressure is at once thrown upon the piston. The effect, it is generally conceded, of a load suddenly applied, is nearly twice what it is when very slowly applied, and we have the full benefit of it here. The too ready use of the governor, where the load is steady, is unmistakably wrong; the position of the cut-off should be changed, if the steam pressure varies.

Expansion is carried to the fullest economical extent, in the circumstances. Steam condensed in expansion, or in the pipe by radiation, and water carried over by steam from the boiler, if it ever is, is re-vaporized by heat from the jacket when the temperature of the steam in the cylinder falls below that in the jacket.

The condenser is made especially to condense the steam, and the sooner it gets there, after it has done its work in the cylinder, the better.

The exhaust-pipe should be large, but short, and clothed so that the passage of steam may not be retarded by cold. It is no more a condenser than the steam-pipe is a generator.

The injection should enter the condenser above the steam, and above a scattering plate; this plate will break the large body of water into small parts, and give it a better opportunity to mix intimately with the steam. Condensation will then be more rapid.

The condenser should not be used as a reservoir, and the air-pumps should be situated low enough to take nearly all the water out of the condenser; the channel-plate will then remain full, and the foot-valve cool. Experience is the best measure of the size of condenser and air-pump; but the former should not be too large, nor the latter too small.

Every joint in the engine should be perfectly tight; and, if the air-bucket brings the water against the delivery-valve with a shock, a small pipe, with a check-valve opening inward, may be led into the upper part of the pump, when all the noise in that part of the engine will cease.

All these things apply as well to the rotative engine as the Cor-

nish; but the latter class, especially those of the Bull engine type, have less rubbing surface than any other. An idea of how much less, may be formed by the following comparison. The Bull engine stands directly over the shaft; the rubbing surfaces are the piston and the piston-rod stuffing-box. Guides are seldom necessary.

The rotative has, in addition to the above, the crank-pin, two journals, bearing, perhaps, a forty ton wheel, the guides, and all connections leading to the shaft. One system of valve-gearing may balance another; but, generally, the Cornish gear is easiest worked. If we tighten the crank-pin brasses a little too much, the pin is, perhaps, red-hot in ten minutes. If we tighten the crank-shaft brasses a little too much, the engine may stop in ten minutes. I have seen these things occur.

Steam in the steam stuffing-boxes, good packing, oil in the gland-cups, the least possible obstruction to the passage of water and steam, and smooth, well lubricated bearing surfaces, go to make the superiority of this machine.

The secrets of the success of the Cornish engineer are these: He has certain work to be done. He has certain power to do it. He makes and keeps a clear track. He applies *all* the power given into his hand. He knows, too, that pumping water is a simple, straightforward business, and he goes about it in a simple, straightforward way. Commencing with the study of first principles, he produces an effective machine.

Most Cornish engineers can do little else than make a good pumping engine, but they do that well. The man that can make a good rotative engine *understandingly*, will not fail to make a good Cornish engine.

As, in Cornwall, fuel is very expensive, and mines are very deep—several over four hundred fathoms—the greatest care is necessary to make them pay, and were the engines badly designed and constructed, or carelessly managed—were the coal wasted in bad firing, leaks or unnecessary friction, as in many of our rotative engines—the duty would soon come down, and the high reputation now enjoyed by the Cornish mining engineer, and his pumping engine, would be heard of no more.

And these are the causes of superiority of the *Cornish Pumping Engine.*

ON THE INFLUENCE OF ARTIFICIAL ILLUMINATION ON THE QUALITY OF THE AIR IN DWELLING-HOUSES.

Translated from the German of a paper of Dr. Gorup-Besanez, and read before the Polytechnic Association in New York, December 26, 1867.

BY DR. ADOLPH OTT.

THE respiratory exhalations of man, and the products of combustion, generated by the various contrivances for artificial illumination, are to be regarded as the chief causes of the unhealthy condition of the air in dwelling-houses, these being an abundant source of carbonic acid gas. Mr. Pettenkofer, the learned savant of Munich, in investigating to what degree the air in dwelling-houses may be charged with this gas, showed that its quantity may serve us as an indicator of the impurity of air, though it is not the only and perhaps not the prevalent cause of bad air, as other changes of the atmosphere (as those produced by organic vapors), are nearly always proportional to the increase of carbonic acid gas. Or, the increase of this gas may indicate how many times a certain quantity of air has been subjected to the respiratory actions of the lungs and bodies, of a certain number of individuals.

The various contrivances for artificial light also exert an injurious influence on the quality of the air in dwelling-houses, which is the worse, the brighter the illumination or the greater the disproportion between the number of flames and the size of the room which is illuminated, and its state of ventilation. As well understood, however, as this may be, it appears that no experiments have been made as to the value which this factor may reach under different circumstances. Dumas only states the important fact, that in gas illumination, both the consumption of oxygen and the production of carbonic acid is very considerable. The question, however, whether the quantity of carbonic acid of an artificially illuminated room can be considered as an indicator for the impure condition of the air, must be investigated further. It cannot be denied that Pettenkofer's statement cannot be applied directly for artificial illumination.

The little that it offers, is strong grounds to search for the prevalent cause of the vitiated condition of the atmosphere of a room in its amount of carbonic acid, but with even less reason can this be adopted for artificial illumination, as it is just in this case that the

imperfect products of combustion are to be considered in their hygienical effects. While on one hand, we may admit with safety, that in an impure air, caused by the respiratory and perspiratory exhalations of man, the increase of other organic gases are proportional to the increase of carbonic acid gas, this does not seem to hold true in the case of artificial illumination; nay, it appears (according to the theory of combustion), as if the quantity of carbonic acid gas and that of the gaseous products of imperfect combustion were inversely proportional to each other. This certainly would be so, if we were able to produce perfect combustion, but it is a well demonstrated fact that in ordinary illuminating flames, perfect combustion does not occur. Perfect and imperfect products of combustion must, therefore, be in a nearly invariable proportion to each other, and the more illuminating material is consumed, the more carbonic acid,* carburetted hydrogen and oxide of carbon will be generated. The amount of carbonic acid will therefore give us always a measure for the whole quantity of the combustion products mingling with the atmosphere in artificial illumination. Experiments in this direction have been made in Germany, by the very able chemist, *Dr. Zoch.* He has also made a series of determinations on the increase of carbonic acid in lighting a room of a known capacity with gas, petroleum and rape-seed oil. Consumption of the lighting material, time and intensity of light, were self-evidently taken into account. The room in which those experiments were made, was of a capacity of 2,540 cubic feet; it had two large windows, one door being opposite, with two blank walls, the third being at the corridor. The building material was good, dry sand-stone. During the experiments, the room was either not, or only momentarily, entered.

Gas illumination was performed by the flame of a common soap-stone burner. The gas was coal gas of good quality, and the consumption reached five cubic feet per hour, the illuminating power being equal to ten and a half normal flames (one normal flame being equal to that of a stearine candle weighing a quarter pound).

Petroleum illumination was performed by a common kerosene lamp, with burner; it gave a bright light without smoke. The spec. grav. of the rectified petroleum was 0·805, the consumption 231 grains per hour, and the illuminating effect equal to three and a half normal flames.

The rape-seed oil illumination was performed by a "moderator"

lamp, with round burner. The consumption was equal to 470 grains of oil per hour, the lighting effect being equal to four and a half normal flames.

The photometric measurements were performed by Bunsen's photometer, the carbonic acid was determined by Pettenkofer's method, with a solution of baryta and oxalic acid. One determination was made before the experiment, and the other after its conclusion. From these trials, it was very soon discovered that the increase of carbonic acid in burning one and the same flame, was

FIRST SERIES OF EXPERIMENTS—GAS ILLUMINATION.

Determination of the increase of carbonic acid in burning a gas flame = 10½ normal flames.

BY DR. ZOCH.

The experiments were conducted in a room with closed double windows, in April, 1866.

Burning time.	Gas consumption in cubic feet.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.	Remarks.
		Before combustion.	After combustion.		
47 min.	4	0·553	1·447	0 894	
47 "	4	0·655	1·466	0·811	
48 "	4	0·543	1·405	0·862	
48 "	4	0·560	1·443	0·883	
48 "	4	0·555	1·395	0·840	Heavy rain, during previous night.
49 "	4	0·736	1·570	0·834	
1 h. 40 "	8	0·334	2·249	1·915	
1 h. 55 "	8	0 512	2·343	1·831	
1 h. 56 "	8	0·636	2·315	1·679	
4 h.	20	0·647	2·954	2·307	

becoming smaller for every following period of time, as natural ventilation was setting in. The trials were therefore continued with each illuminating material until the increase of carbonic acid gas had reached its maximum. The results of Dr. Zoch seem to me not to be without interest, and well adapted to fill a void hitherto existing, and this may justify their publication.

These determinations being made with double windows, it seemed not to be without interest, to repeat them with single windows, in order to perceive the changes contrasted with natural ventilation. The results communicated in the following table, prove that this influence was very small.

THE EXPERIMENTS WERE CONDUCTED IN APRIL AND MAY, 1866.

EXPERIMENTER, DR. ZOCH.

Burning time.	Gas consumption in cubic feet.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.	Remarks.
		Before combustion.	After combustion.		
48 min.	4	0·643	1·496	0·853	
48 "	4	0·625	1·432	0·807	
49 "	4	0·624	1·372	0·748	Very windy.
52 "	4	0·818	1·684	0·866	
1 h. 43 "	8	0·798	2·412	1·619	
1 h. 45 "	8	0·391	2·043	1·652	Rain.
1 h. 46 "	8	0·534	2·216	1·682	Heavy wind.
1 h. 30 "	12	0·487	2·389	1·842	
2 h. 32 "	12	0·685	2·569	1·884	
4h.	20	0·642	2·906	2 264	

From these experiments, we learn the interesting fact, that in burning a single gas flame in an ordinary sized room for several hours, the amount of carbonic acid of the atmosphere may reach three parts per thousand, viz: a quantity only to be met with in hospitals, prisons and garrisons, where the process of respiration of many individuals is going on. Even the burning of a gas flame during the time of forty-eight minutes, with the small gas consumption of four cubic feet, is sufficient to produce a quantity of carbonic acid gas, which is twice as great as that of the atmospheric air. It may also be seen that the increase of carbonic acid gas remains approximatively the same for equal times and at different observations, while it does not increase proportionally for a longer time, as then natural ventilation is constantly becoming more effective. These circumstances explain the above figures so well, that further discussion appears superfluous.

SECOND SERIES OF EXPERIMENTS—PETROLEUM ILLUMINATION.

Determinations of the increase of carbonic acid in burning a kerosene lamp. Lighting effect = 8½ normal flames.

EXPERIMENTER, DR. ZOCH.

Burning time.	Kerosene consumption in grains.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.
		Before comb.	After comb.	
1 h.	235·33	0·593	1·072	0·479
1 h.	235·33	0·550	0.975	0·425
2 h.	470·61	0·786	1·438	0·652
2 h.	470·61	0·675	1·440	0·765
3 h.	705·15	0·606	1·441	0·865
4 h.	944·31	0·697	1·577	0·880

In burning a kerosene lamp, the production of carbonic acid gas is considerably less than in burning a gas flame; the numbers, however, cannot be directly compared, since they are not reduced to the same lighting effect. We shall see, that in this case, kerosene

illumination generates even more carbonic acid gas than does gas illumination.

THIRD SERIES OF EXPERIMENTS—RAPE-SEED OIL ILLUMINATION.

Determination of the increase of carbonic acid in burning a "moderator" lamp with Argand-burner. Lighting effect = 4½ normal flames.

EXPERIMENTER, DR. ZOCH.

Burning time.	Rape-seed oil consumption in grains.	Carbonic acid of the atmosphere per thousand.		Increase of carbonic acid.
		Before comb.	After comb.	
1 h.	416·61	0·908*	1·244	0·336
2 h.	941·23	0·513	1·162	0·649
3 h.	1,296·12	0·623	1·367	0·744
4 h.	1,820·74	0·769	1·537	0·768

As seen from this table, rape-seed oil illumination generates the smallest amount of carbonic acid gas, although the "moderator" lamp has a greater lighting effect when compared with the small kerosene lamp, and notwithstanding the greater consumption of oil by the latter. After four hours, the quantity of carbonic acid in the room amounted to 1·537 per thousand, that is, only half as much as generated by an ordinary gas flame during the same time. From these experiments, it is obvious that we procure pure and brilliant light of gas illumination at the expense of pure atmosphere.

The numbers communicated in the foregoing tables can, however, not be *directly* compared with each other, they being not reduced to the same lighting effect. We have done this in the following table, where the increase of carbonic acid in the three modes of illumination is calculated for the space of 100 cubic metres (130·8 cubic yards), and upon a lighting effect of ten normal flames, at the time of one, two, three and four hours.

* This amount of CO_2 is to be accounted for by the presence of many individuals in the room previous to the experiment.

Burning time.	Increase of CO_2 per thousand.		
	For kerosene.	For gas.	For rape-seed oil.
1 h.	0·929	0·708	0·587
2 h.	1·456	1·342	1·038
3 h.	1·779	1·513	1·190
4 h.	1·811	1·562	1·229

These experiments allow some important conclusions. First, we see that kerosene yields more carbonic acid gas than street gas, and the latter more than oil; in accordance therewith, Dr. Zoch observed that in kerosene illumination the atmosphere was more vitiated when the amount of carbonic acid had reached 1·779 per thousand, a phenomenon not at all observable in rape-seed oil illumination, and in a scarcely perceivable degree in gas lighting. As we cannot possibly believe that the carbonic acid alone is the cause of this impurity, we have to account for it in the products of imperfect combustion, and hence we obtain another argument for the hypothesis, that the amount of carbonic acid generated in illumination may be taken as an indicator for the other changes in the air. A delicate nose detects in petroleum illumination very soon the products of imperfect combustion. The foregoing numbers also show us that for the three modes of illumination, a maximum in the production of carbonic acid gas is reached after three hours.

Though it may seem presumptive to generalize conclusions from the above numbers, they nevertheless seem to be useful in the formation of hygienic postulates. They firstly prove the excellency of good rape-seed oil illumination, which charges the air the least with extraneous impurities. Of no great practical importance is it that kerosene contributes most to vitiate the air, as this mode of lighting is not very general, but it is a very different affair with gas illumination. Who has not noticed of late years in the illumination of the stores, theatres, concert and political halls of our great cities the fact that each attempts to rival his neighbor in the glaring effect of gas light, but at the same time, who has not also made the observation that the greater the light, the greater the oppressiveness and vitiation of the atmosphere? We are of the opinion that this sen-

sation of discomfort is partly to be attributed to the radiant heat, also an effect of gas illumination. Briguet, a French physicist, has found that a gas burner, consuming 4·87 cubic feet per hour, heats 1·74 cubic yards of air from 32° to 212° F. At a distance of one foot from a gas flame of 1·14 inches diameter, which was surrounded by a glass cylinder, the thermometer rose 3·6 degrees, but at a distance of only 6·3 inches, not less than 10·8 degrees. Another source of this discomfort, however, is undoubtedly and even in a well ventilated room, the vitiation of the air spoken of. Individuals who are compelled to remain in a brightly illuminated room for some time, complain soon of impediment in breathing, a dry heat in the throat, a tickling sensation in the larynx, dry and fatiguing cough. With people of weak chests and tuberculous constitution, this kind of atmosphere agrees least. To ascribe those symptoms to the effect of heat alone, would certainly be unjustifiable.

There are many unfounded prejudices against the use of gas in private houses; for small rooms with imperfect ventilation, this mode of lighting is undoubtedly not well adapted, and all the disadvantages noticed will appear in a higher degree; I doubt, however, very much, if those accustomed to the bright light and convenience of gas illumination, will be induced by such suppositions to quit the use of so very comfortable an article, before ill health has been the punishment for the neglect. Whether the atmosphere of a room when it is charged with three per thousand of CO_2 in consequence of artificial illumination, will have the same effects as an air vitiated to the same degree with this gas by respiration and perspiration, and whether the other products hereby generated are of equal effect, is a question yet to be decided, but worthy of consideration.

Electro-Plating Iron with copper and brass. The process so successfully carried out in France for this purpose, has been recently published, and is very simple. The iron object is coated with a varnish of resin, dissolved in benzine. This is then coated with plumbago, as in electro-plating non-metallic bodies, and the copper then deposited as usual. Iron, as all know, takes a light coat of copper with singular ease, by electric decomposition or chemical substitution; but as soon as any effort is made to thicken this layer, it peels off. To overcome this difficulty, has hitherto defied the ingenuity of many experimenters, but the question has at last received the curious practical solution above noticed.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

BY PROF. HENRY MORTON, PH D.

(Continued from page 203.)

IN order to illustrate and bring vividly before your minds some of the strange conditions which we have found to exist on the moon's surface, I have caused to be prepared and now bring by a signal upon the screen, a series of imaginary views of lunar scenery, which are intended to represent, as well as may be, what would appear to one could he place himself upon our satelite, and in that desolate, sun-scorched, airless, and therefore soundless as well as lifeless solitude, look about him and observe the objects by which he was surrounded.

The first of these pictures which I bring before you, is a view of the vast expanse known as the Mare Imbrium, or Sea of Showers, seen from the spurs of the Apennine range, which skirts its south-eastern boundary, and looking towards the north, where the lunar Alps wall-in the plain, and terminate the view.

From the foreground in this picture, Plate IV., to the most distant object, is a space of 500 miles, so that even at the outset we must make an effort of the imagination to grasp such a stretch of view, as was never seen by human eye. In the foreground, to the extreme right, are seen two volcanic craters; the nearer of these is called Autolycus (42 Pl. II)., and the further, with a central cone, Aristillus (43). A little to the left of these, is seen the grand volcanic ring of Archimedes (41), which is fifty miles in diameter and about one mile in height.

From the midst of the plain, but nearer to its further border, rises an abrupt pinnacle of rock, known as Pico, 7,000 feet high above the surrounding plain, and casting a shadow, which, like that of

Mount Athos, noticed by Plutarch as reaching to Lemnos, stretches for miles outward from its base.*

In the distance is seen the range of the Alps, which by its angularity and abruptness of ascent, bears evidence to the absence of all those softening and leveling influences of air and water, which have rounded the sharp outlines and crumbled down the abrupt surfaces of our terrestrial ranges. To the left, and setting somewhat back among the Alpine peaks, we see the rugged flanks of Mount Plato, a volcanic ring without any interior cone. Near the extreme left of the picture,† we see one of the smaller volcanoes, Timocharis, whose crater is but about eighteen miles in diameter, and a little to the right of this and more in the foreground, is one of those sunken craters or volcanic wells which are encountered in almost all parts of the lunar surface. In fact, careful measurement shows us that many of the large craters have their interior plains depressed considerably below the surrounding surface of the planet. Thus, Eratosthenes (38), which terminates the Apennine chain to the west, while lifting its exterior ring 3,000 feet above the plain of the Mare Imbrium, has its interior level surface 3,000 below the same level, or 6,000 feet beneath the exterior ridge, the rocks falling on the interior, in a vertical precipice, to meet the inner plain, from the centre of which a conical peak towers up, *not* in the *air*, but towards the sky.

Another feature in this view, worthy of remark, is the black sky studded with stars, overhanging a scene brilliantly illuminated by the sun. This is, however, we have every reason to believe, true to nature; for, as we know, the light reflected from our sky is due to the presence of watery particles suspended in the air, and scattering the impinging sun-rays in all directions; and as there is no atmosphere and no water in the moon, no such action can there take place, but the sun's rays must proceed undeflected in straight lines to the surface of the planet, and thus fail to produce any such diffused illumination; so that the sun itself would appear as a disk

* Mount Athos, on the coast of Macedonia, rises abruptly from the sea to a height of 6,349 feet, and according to the statement of Pierre Beleu (quoted in the Cosmos by Humboldt), that "its shadow reaches to the broken figure of a cow in the market place of Mycene," must thus extend its wand of shade over the Mediterranean for thirty miles.

† For several ideas embodied in this picture, and many other valuable suggestions, we are indebted to a little work entitled "The Lunar World," by the Rev. J. Crampton, Edinburgh.

of intense brightness, set in a sky dark as that of our blackest midnight, and sprinkled with the larger stars, the eye being rendered incapable of perceiving the smaller ones by the glare of nearer objects.

We now bring upon the screen another illustration of lunar scenery, which we might, by analogy, call a moonlight view; this being a case wherein the revealing light comes, not directly from the sun, but only as reflected from the illuminated face of a planet. In this case, the earth acts as a moon to her own moon. That light is in fact so reflected by the earth, and does so illuminate the moon, we know by actual observation; for the light by which at new moon we often see the entire disk of our satellite faintly shown, is simply that received from the earth at that time, presenting an almost "full face" to the moon. The phenomenon to which I refer is that called by us in common and ideal language, "the old moon in the new moon's lap," or by the French, "la lune cendre" (the ash-colored moon).

That this doubly reflected light should be very faint when at last it reaches our eyes, will appear natural, when we remember that the full moonlight is but $\frac{1}{100000}$th of that received from the sun, and that, therefore, received by the second reflection, must be again decreased in a somewhat similar proportion.

The picture now before us (see Plate I., facing page 59), represents the volcano Copernicus, which formed a conspicuous object in most of our lunar photographs (see Pl. II)., and which rises from the northern region of the Mare Nubium, on the southern flank of the Karpathean mountains, which form a prolongation of the Apennines towards the west, and separate the Seas of Showers and of Clouds (Mare Imbrium and Mare Nubium).

The scene here represented, is that which we may suppose would appear to a spectator looking southward from the summits of the Karpathean mountains, over the rugged ground of the Mare Nubium, and with the craters of Eratosthenes and Stadius to the left. To illuminate this desolate region, we have the subdued light of a "full earth," which, though in area sixteen times larger than our moon, would, it is probable, by no means reflect an equally increased proportion of light, since the vast surfaces of water and of vegetation would be far inferior in reflecting power, to the volcanic lava and glittering rock which compose exclusively the lunar surface.

On the "earth-moon" is seen in the picture an indication of the American continents and Pacific ocean, as also certain parallel cloud-bands, such as we also see on the planet Jupiter, and which would doubtless be produced by the action of our trade winds.

This picture is photographed from a painting made by Mr. James Hamilton, expressly for the purpose, together with other views which we shall see and discuss presently, and conveys in an admirable manner the idea of vastness and desolation, which must be the characteristic of such a scene.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

Prof. of Descriptive Geometry, &c., in the Rensselaer Pol. Inst, Troy, N. Y.

(Concluded from page 212.)

Among the more specific "ideas of reason," "first truths," "intuitions," are those of time, space, personal identity, objective reality of sensible objects, and causes as required by existing effects.

Here it is to be remembered, what is not often expressly stated, that man's finiteness finds limitations to its *beginnings* as well as to its advance. That is, there are fundamental ideas as starting points of all thought, *back of which* we cannot go any more than we can go *forward* beyond a certain point.

But to return, under, and in certain important respects, subject to the supreme powers, reason and will, are ranged the *working faculties of the understanding*, and the *enlivening*, *prompting* and *motive powers*, called the *sensibilities*.

These working faculties may be known as the

Powers Representative.

Conception = the forming of an *idea* = the mental representative of a *fact*, of the *real*. } From *perception* = the impressions made on the mind through the senses. From *consciousness* = the impression made on the mind by its own working.

Imagination = the representation of the *ideal*.

Memory.—The Reflective Power.

Abstraction = the elimination of the attributes of things, for separate contemplation, and as a basis for comparison, classification, and generalization.

Judgment = the affirmation or denial of agreement between two particulars.

Reasoning = the derivation of one judgment from another.

The sensibilities are generally known as—

The Emotions of:
- Cheerfulness or melancholy.
- Joy or grief.
- Love or hatred.
- Honor or shame.
- Etc.
- Anger.
- Terror.
- Surprise.
- Etc.

Desires of:
- Property.
- Knowledge.
- Position.
- Power.
- Approbation.

Affections for:
- Home.
- Country.
- Mankind.
- Friends.
- Etc.

Coming now to applications, after delays which we hope have not unreasonably taxed the reader: The *nature and relations of good*, and the *structure of the human mind*, as just outlined, on the one hand, and the *demands of civilized life* upon all who share it, on the other, are the *facts* to be regarded in organizing and administering an institution of learning, either general or technical.

In the personal and material composition of an institution, and of its course of study, the full idea of *good* is to be realized to the utmost within the limits afforded by the scope of the institution; so that for example, as *a cardinal principle*, the *whole being* and not merely the *technical knowledge* of the teacher should be favorably brought to bear upon the *entire* life of the student, as well as primarily and mainly upon his attainment of the knowledge-qualifications for his chosen pursuit.

An institution thus becomes a unit, though a compound one, and almost a truly personal one, through the vigor of the co-operating life which fills it. It thus has a life and individuality of its own, and this life should be full of *beauty* as the charming surety that, in its essence, it is good.

The institution should be devoted to *truth*, in its promises and performances, in every direction, by every one; without even momentary pleasure in either offering or accepting appearance for reality, or the work of any other for that to be done by each one's proper self.

And in its means and methods, economy, time and labor should be sought so as to accomplish results at once most real, most valuable, and most enduring, with the least obstruction from imperfect arrangements, inadequate means, or unskillful methods. Thus will the idea of *right* be secured; not merely to attain a proposed end most *truly*, but most easily, readily and efficiently.

The possession of all these invaluable characteristics, even par-

tially obtainable only by costly effort, is the incommunicable secret of every institution, as well as person, that has them.

Taking up next the bearings of the mental structure upon the conduct of an institution, the joint culture of the will and the reason, as they have been defined, should be secured by provisions at once liberal and justly regulated, for their exercise. Perhaps this can in no way be better accomplished, having regard also to the cardinal doctrine of the perfect unity, though a complex one of the institution, than by delegating the regulation of various details of administration and usage to class organization, with the reservation of an advisory and, ultimately, of course, of a veto power. Such a course appears as the happy mean between the irksome restraint of an authoritative code, so minute as to leave nothing to be done freely, and a looseness which relies on nothing more than previous social good breeding, the pervasive influence of general surrounding civilization, and prevalent youthful instincts of deference to its legitimate guardians and teachers, as guarantees of good behavior.

Experience, moreover, of the extent to which even these guarantees can be relied on, gives happy promise of the best results from the strong added appeal to regard for honor, and reputation for good judgment, contained in the course here proposed. Experience further shows, too, how carefully older judgments are consulted by youth when placed in the simplest positions of responsibility in matters in which they feel a pure enthusiasm. So that in this method of admitting them to an appropriate share of the work of conducting affairs, we find realized the natural idea of younger judgments exercising themselves in happy and invigorating freedom, within certain limits of fundamental principle, established by those of greater and more studious experience.

A capital omission, however, would exist if no reference were here made to one point, requiring special attention in the authoritative oversight of the main features of principle and practice incorporated in student organizations, so far as these directly affect the rights and powers of an institution, and of its members in their individual capacity. Youth is usually ardent in its enthusiasms to a degree which often becomes passionate, and that, too, sometimes, irrespective of the real importance of the question at issue. As soon as passion sets in, opposition, however, conscientious in principle, courteous in manner, and justly defensive of innocent personal rights, is too apt to be visited with abuse which is both tyrannical

in spirit, and odious in expression. Of course, the noblest resistance to such abuse is a moral strength against which the ***strength*** of *passion*—which is the ***weakness*** of the ***person***—dashes itself in vain. But virtue, modest in its immaturity, in a minority, and unsupported where it has most right to look for effectual support, must not be unjustly taxed with excessive demands upon it. Those having both the power and the right to sustain it should do so, and as prevention is better than cure, this should, and, as experience shows, can be accomplished in the manner proposed, viz: by securing the adoption by class organizations, wherever these are allowed to exist, of certain provisions as guarantees of due recognition of the ultimate authority of the institution, and of the personal rights of its members.

Or, to repeat, in the negative form, owing to the importance of the subject, everything should be excluded from the rules and practices of student organizations which could naturally tend to occasion or to intensify differences between officers and members of the institution or embarrass the settlement.

The same end here discussed, of training the will in connection with the reason, may further be promoted by fostering all those less hazardous organizations whose object is the culture of some improving art or manly sport, rather than the assertion and exercise of personal influence, in matters of general administration. Moreover, if instructors sincerely aid and sympathize with such organizations,—musical, boating, literary, or scientific,—the idea of unity is as well expressed as in the former case. But the agencies through which it is expressed being so different in the two cases, the employment of both is necessary to the most intimate union of all interests, and is therefore worthy of the superior thought, patience, care, and—to tell the whole—love necessary in attaining this ideal union.

Finally, in attaining this end, the whole range and compass of the sensibilities must be known and skillfully handled, as are those of a great organ. But this opens up to thought a vision of harmonies or discords of being and living as numberless as the combinations of audible harmony. Wherefore we stop at once, and trust to present the promised curriculum in another article.

Williamstown, July, 1868.

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 210.)

On the contrary, when persons think they are able to earn their own living and a little more, the more pure air they breathe, provided they have an abundance of good wholesome food and plenty of exercise, the greater amount of physical or mental labor they can perform.

The pecuniary nature of health is but imperfectly understood. It was found in England that when a certain portion of the tenement houses, belonging to some of the large factories were well ventilated that the tenants required more food, it cost them more per week to live and supply themselves and families with the necessaries of life.

They consequently could not work so cheap from week to week as those living in *un*-ventilated houses. This appeared on its face to be a strong argument against the pecuniary value of ventilation. But let us take a more careful view of this. Every animal or machine has its market value—a horse is worth so much in the market, so is an ox and a sheep, and to our great shame we have until very lately had a regular market price for a man and a woman. Now, owing to even the little intelligence which it was formerly admitted that a slave had over a horse, we would give four or five times as much for a man as for a horse.

A good man before the war was worth from twelve to fifteen hundred dollars, and some two thousand.

The superior intelligence and energy of any one here, and the greatly enhanced prices since the war, in connection with the fact that one man with brains can manage machinery that is sufficient to do the labor of twenty horses, adds greatly to the value of an intelligent man,—or, in other words, any manufacturer or capitalist would be very willing to give $5000 for the services for life of any intelligent, able-bodied man between the ages of twenty and thirty years, taking all the risks of his living, and clothing and feeding him for life.

Now, that $5000 is the entire capital of many young men, sup-

pose a large manufacturer wants hands at piece-work, and this young man, say, is just married, and anxious to get along, takes the work just as low as he possibly can, he finds by saving a little in his food, and by keeping his house shut up tight, with an air-tight coal stove he can save coal, and thus at the end of the week can just make both ends meet, or, in other words, can pay expenses.

Now he does not calculate how much of his original $5000 he put into that work for the capitalist—but by the reduction of his physical strength he has used a shilling's worth a day of that capital; six shillings a week, twenty-four shillings a month, and so on.

Thus drop by drop does that wealthy capitalist absorb the very life blood. Ounce by ounce are the sinews of this poor man bartered away and appropriated by the capitalist.

He is daily growing weaker as his family cares increase, and in a few years, with a wife and family of small children entirely dependent on his daily labor for their food, clothing and schooling, he finds himself broken down in health with a ruined constitution, and he is then cast aside for another, younger and more vigorous man, who will engage to work cheaper, and can afford to do so by using a shilling's worth daily of his $5000 capital the same as his predecessor.

This arises from the ignorance of these laboring people of the true value of health and of the proper means of preserving it. What is the result.

A nation of unhealthy people must inevitably become a nation of paupers, but a healthy nation will surely become a wealthy nation.

For a proof of this assertion we have only to look to the manufacturing districts of England, as they are amongst the most unhealthy. Could they support themselves if their trade with foreign and newer countries was cut off? Undoubtedly not. And look at New England, what does the census of her manufacturing states give? A very small increase of population indeed.

And the manufacturing wards of this city, too, will show a greater amount of ill health and pauperism, which always go together, than the non-manufacturing districts.

Now, how can this be remedied—by any simple act of legislation? I answer no! Not even the fiat of that Supreme Congress now gathered under our beautiful flag, representing as it does the most powerful nation on the face of the earth, could reconstruct

society in this respect. No, you must teach the people, the laboring man, the bone and sinew of the nation, the value of health and how preserve it. The parents then will be but in the prime of life when their children shall have grown to manhood, and they in their turn will be competent to care for their parents in old age.

I want each of you to become a lecturer on ventilation; I do not mean merely to give three or four lectures in a whole year—but to lecture every day of your lives, because there is not one of you here but what has some friend now suffering for the want of pure air.

I want you, too, to go to the home of the laborer, the man that is not here to-night—he whose laborious toil from early morn to dewy eve, demands rest in the evening, instead of allowing him the privilege of attending lectures.

I have visited many such, and find that a few simple, kindly words of explanation are always gladly received, and frequently have their good effect in inducing them to remove a fire-board in a sick-room, or by putting on an extra blanket, to allow the windows to be opened a little more every night, and thus do a great kindness to these poor, worthy people, by getting two cubic feet of pure air to enter, where but one entered before.

Could Philadelphians but be fully aroused to the great importance of this thing, the mortality of this beautiful city might be reduced for the year 1868, perhaps even more than it was for the year 1867, because I believe there is no city on the face of the earth so favorably situated for an immediate reformation in this respect as this city, as all the houses are built so isolated, with a window and fire-place in nearly every room: while in New York one-half of the population live in houses of entirely different construction, nearly half the sleeping-rooms being merely dark closets into which the purifying rays of the sun and the pure external air can never enter.

And this is a very serious defect, which nothing but tearing down and re-building can fully remedy; although a good artificial ventilation might greatly improve them. Philadelphia has the advantage in this respect, very decidedly.

If it were in any way possible to get all the physicians stirred up, to make some active exertions towards inducing the people to be more careful about the ventilation of their houses, it might have a wonderful effect.

This, however, is hardly to be hoped for, as a regular old school Philadelphia physician is probably about as respectable and proper and conservative a man as the sun shines on. We could scarcely find a greater curiosity than the name of a regular old school Philadelphia physician at the head of a recommendation to public favor of any new thing, no matter of how much public utility it might be.

(To be continued.)

Bibliographical Notices.

Aniline and its Derivatives. A treatise on the manufacture of Aniline and Aniline Colors. By M. Reimann, Ph. D., L. A.M., to which is added, in an appendix, the Report on the Coloring Matters Derived from Coal Tar, shown at the French Exhibition of 1867. By Dr. A. W. Hofmann, F. R. S., M. M. G. de Laire, and Ch. Girard. The whole revised and edited by William Crookes, F. R. S. Published by John Wiley & Son, Astor Place, New York.

In giving to the American public a reprint of this work, its present publishers have filled a vacancy much deplored by all who are in any way interested in the great and daily increasing industry of Aniline Colors, and by all who take an interest in the progress of the age, as shown in its manufacturing improvements and scientific discoveries.

It is now scarcely ten years since the first practical step was made in the direction of this manufacture, and yet it has grown to be one of the first rank among existing processes. By the late discovery, of an aniline green, the gamut of aniline colors has been filled out; and we now have every color of the prismatic scale represented in this admirable material, the increased demand for which is keeping pace with the daily increasing facilities and economy in its manufacture. The present work describes from the beginning and with such full explanation as renders every point plain to any one possessing even a general knowledge of chemistry, each process in manufacture, from the primary benzine to the latest derivative, and by means of numerous illustrations shows the form and propositions of the apparatus employed.

The report on the colors shown at the exhibition is written by Dr. Hofmann with the life and interest which characterize his productions, and is enlivened by many incidents in connection with the history of the subject, which add much to its vivacity.

We can cordially commend this work to all manufacturers and men of science who are interested in its subject.

A Treatise on Optics; or, Light and Sight, theoretically and practically treated with the application to Fine Art and industrial pursuits. By E. Nugent, C. E., (103 illustrations.) Published by D. Van Nostrand, New York: For sale by J. B. Lippincott & Co., Philadelphia.

For a long time nothing has been more needed than a good work on practical optics. Neither in our language nor in any other, we believe, does such a thing exist, as a book which will convey to a reader any notion of the various principles and facts, which are every day applied either ignorantly or with intelligence by all those who are engaged in the construction or use of optical apparatus. We have a sufficiency of optical works, it is true, but these, as a rule, concern themselves with the recondite and unpractical parts of the subject, and while they treat with admirable minuteness and thoroughness of research, such subjects as those of interference and circular polarization, pass over almost in silence the practical problems relating to the correction of the various aberrations of lenses, to the remedy of distortion, and to obtaining the best results under different conditions.

We should, therefore, hail with pleasure the appearance of a work, such as that which is now before us, which though, as its size necessitates, but an essay towards the full treatment of the vast subject it attacks, yet opened the road in the right direction, and in some respects, did its work well. The first part of the book is taken up with the exposition of the general facts, laws and theories of light. The subjects of refraction and reflection are well discussed, and the actions of lenses described, with many convenient rules for the calculation of focal lengths of single lenses; this being, in fact, an abstract of the corresponding part of Brewster's Optics. But we find no notice on the subject of equivalent foci, and the methods requisite for measuring the lengths of compound lenses.

On the subject of dispersion our author seems to live about ten years behind the present age, and gives us the knowledge and theo-

ries of that dark period, with an entire ignoring of the whole subject of spectrum analysis, and all the late discoveries in that direction by Bunsen, Kirchoff, Tyndall, Miller, Stokes and others, which is certainly very extraordinary.

He also propounds a theory of colors which much resembles that of Goethe, and which, though *perhaps* tenable in *his* time, cannot now have a leg left to stand upon, thanks to the spectrum discoveries above noticed.

We observe that Mr. Hunt is frequently quoted, and presume that the author of Elementary Physics, Researches on Light and the Poetry of Science is the authority; but without entering into an elaborate criticism, it will appear, that an author who in illustrating the law of gravitation says:* "If the sun and earth were equidistant from Jupiter, the influence of that planet would be the *same on each and would draw them through the same space in the same time*," cannot be a very safe guide; not to mention that the "Researches on Light" were made nearly twenty years ago, since when the science of Optics has effected the most prodigious advances in facts and theories.

The latter portion of this book, which is taken up with the description of various forms of lenses and optical instruments, contains some things of value, though enriched with copious omissions of almost all American inventions in this direction, and with a little too many of Mr. Dallmeyer's optical combinations, for photographic work.

The Bankers' Magazine for October. Edited by J. Smith Thomas, 41 Pine Street, New York.

This number contains an elaborate article on the past and present production of gold and silver, throughout the world.

I. The production since the discovery of America. II. The production in the Nineteenth century to the year 1848. III. The production since the discovery of gold in California. IV. The present annual production in all countries. V. Annual report of the General Land Office, U. S., on Gold and Silver. VI. Special report of Mr. J. Ross Browne, on the Pacific Gold Region. VII. Special report of Mr. James W. Taylor.—The relative supply of both metals, past and present.—The annual and aggregate supply throughout the world, with the views of Messrs. Jacob, Newmarch and Chevalier and others.

Also a list of 360 Savings Banks in New England and New York, number of depositors and amount of deposits in each.

* **Elementary Physics, by Robert Hunt, p. 47.**

A COMPARISON *of some of the Meteorological Phenomena of* AUGUST, 1868, *with those of* AUGUST, 1867, *and of the same month for* EIGHTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	August, 1868.	August, 1867.	August, for 18 years.
Thermometer—Highest—degree	89·00°	86·00°	97·00°
" date	30th.	14th.	2, '56; 4, '59.
Warmest day—mean	83·00	80·67	88·50
" " date	3d & 30th.	19th.	10th, '63.
Lowest—degree	61·00	59·00	47·00
" date	17th.	1st.	26th, '56.
Coldest day—mean	71·67	67·50	59·00
" " date	17th.	31st.	26th, '56.
Mean daily oscillation	10·65	12·44	14·99
" " range	2·87	3·68	3·65
Means at 7 A. M.	74·26	71·02	71·04
" 2 P. M.	80·90	78·18	81·00
" 9 P. M.	77·37	74·56	74·12
" for the month	77·51	74·59	75·39
Barometer—Highest—inches	30·279	30·210	30·279
" date	28th.	31st.	28th, '68.
Greatest mean daily pressure	30·209	30·128	30·229
" " " date	28th.	26th.	20 & 31, '55.
Lowest—inches	29·627	29·578	29·356
" date	2d.	16th.	20th, '56.
Least mean daily pressure	29·653	29·599	29·388
" " " date	2d.	16th.	20th, '56.
Mean daily range	0·102	0·108	0·096
Means at 7 A. M	30·006	29·967	29·872
" 2 P. M	29·976	29·939	29·843
" 9 P. M	29·986	29·944	29·863
" for the month	29·989	29·950	29·860
Force of Vapor—Greatest—inches	0·843	0·815	1·024
" date	3d.	14th.	1st, '54.
Least—inches	·386	·317	·268
" date	17th.	30th.	Often.
Means at 7 A. M	·620	·602	·586
" 2 P. M	·625	·609	·594
" 9 P. M	·644	·645	·614
" for the month	·630	·619	·598
Relative Humidity—Greatest—per cent	83·0	92·0	100·0
" date	5th.	15th & 22d.	26th, '54.
Least—per cent	39·0	36·0	27·0
" date	14th.	11th & 26th.	1st, '60.
Means at 7 A. M.	72·3	78·7	76·1
" 2 P. M.	58·8	63·4	56·5
" 9 P. M.	67·9	75·2	72·8
" for the month	66·3	72·4	68·5
Clouds—Number of clear days*	4·	9·	9·2
" cloudy days	27·	22·	21·9
Means of sky covered at 7 A. M	66·1 per ct	63·2 per ct	56·8 per ct
" " " 2 P. M	68·7	63·5	61·7
" " " 9 P. M	46·1	44·5	42·0
" " for the month	60·3	57·1	53·5
Rain—Amount—inches	2·55	16·840	4·411
No. of days on which rain fell	10·	15·	10·1
Prevailing Winds—Times in 1000	s 46°44′ w. 271	s 52°26′ E. 094	s 71°31′ w. 125

* Sky one-third or less covered at the hours of observation.

A COMPARISON *of some of the Meteorological Phenomena of the* SUMMER *of* 1868, *with those of* 1867, *and of the same Season for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	Summer. 1868.	Summer. 1867.	Summer. for 17 years.
Thermometer—Highest—degree	98·00°	91·00°	101·00°
" date	July 14.	July 4.	July 17, '66.
Warmest day—mean	90·50	85·67	92·33
" " date	July 14.	July 4.	July 17, '66.
Lowest—degree	51·00	48·00	42·00
" date	June 3.	June 9 & 11.	June 5, '59.
Coldest day—mean	56·50	53·50	53·50
" " date	June 11	June 9.	June 9, '67.
Mean daily oscillation	13·31	14·73	15·58
" " range	3·37	4·02	4·09
Means at 7 A. M.	72·88	70·21	71·25
" 2 P. M.	81·78	78·87	81·20
" 9 P. M.	76·34	73·08	73·97
" for the Summer	77·00	74·05	75·47
Barometer—Highest—inches	30·292	30·309	30·309
" date	June 4.	June 11.	June 11, '67.
Greatest mean daily pressure	30·274	30·270	30·274
" " " date	June 4.	June 11.	June 4, '68.
Lowest—inches	29·623	29·474	29·182
" date	July 25.	June 3.	June 11, '57.
Least mean daily pressure	29·648	29·586	29·262
" " " date	June 20.	June 3.	June 11, '57.
Mean daily range	0·095	0·103	0·096
Means at 7 A. M.	29·989	29·971	29·855
" 2 P. M.	29·958	29·946	29·820
" 9 P. M.	29·969	29·951	29·836
" for the Summer	29·972	29·956	29·837
Force of Vapor—Greatest—inches	0·911	0·925	1·059
" date	July 12.	July 6.	June 30, '55
Least—inches	·255	·183	·142
" date	June 4.	June 10.	June 14, '61.
Means at 7 A. M.	·609	·559	·572
" 2 P. M.	·632	·558	·580
" 9 P. M.	·649	·598	·604
" for the Summer	·630	·572	·585
Relative Humidity—Greatest—per cent.	94·0	95·0	100·0
" date	June 12.	June 25.	A26'54, J6'56
Least—per cent.	35·0	28·0	22·0
" date	June 30.	June 10.	June 16, '63.
Means at 7 A. M.	74·0	74·5	73·3
" 2 P. M.	57·9	56·7	54·5
" 9 P. M.	70·6	72·4	71·2
" for the Summer	67·5	67·9	66·3
Clouds—Number of clear days*	16·	31.	25·7
" cloudy days	76·	61·	66·3
Means of sky covered at 7 A. M.	66·9 p. c.	60·6 p. c.	59·0 p. c.
" " " 2 P. M.	66·6	61·5	61·1
" " " 9 P. M.	54·0	46·8	43·6
" " " for the Summer	62·5	56·3	54·6
Rain—Amount—inches	8·87	30·820	12·628
No. of days on which rain fell	30·	38·	32·7
Prevailing Winds—Times in 1000	s 43°2′ w. 122	s86°49′w.071	s70°26′w.164

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] NOVEMBER, 1868. [No. 5

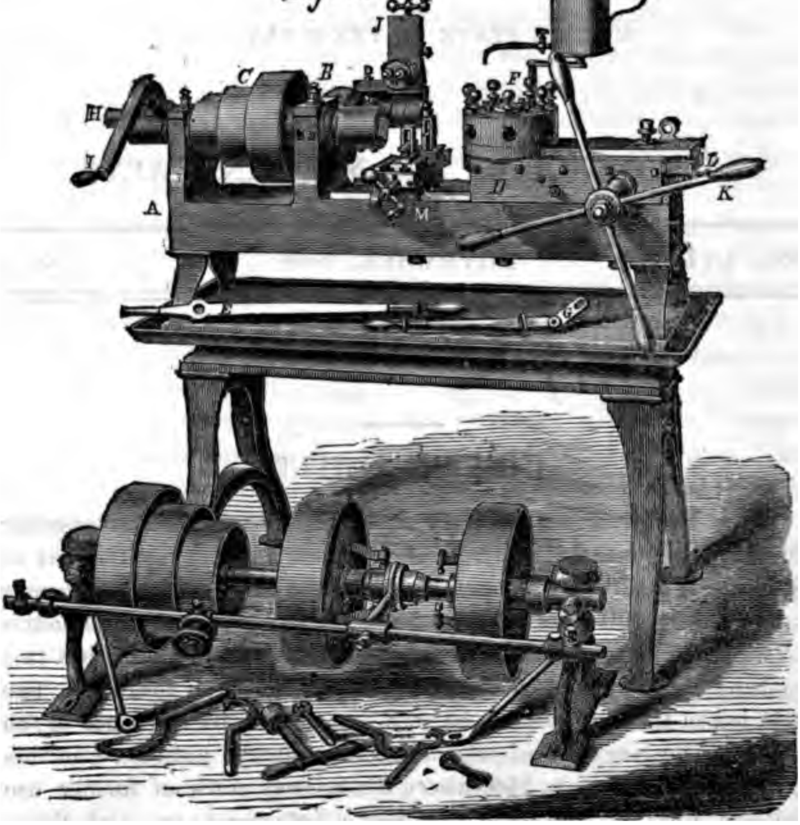
EDITORIAL.

ITEMS AND NOVELTIES.

New Railway across Egypt.—We observe that the opening of the new route by rail from Alexandria to Suez, by the way of Zagazig, is announced as having taken place last month. The former route was by rail from Cairo to Suez, the distance from Alexandria to Cairo being traversed by canal and the Nile, or by rail; but this making a considerable detour, and lengthening the journey. The relation of these routes can be well understood by reference to the map of the Suez Canal and adjacent country, published in this *Journal*, Vol. LV., p. 236, where the railway route of former use follows pretty closely the post-route between Cairo and Suez, through a very rough and difficult country, while the portion of the new line which corresponds with this, from Zagazig to Suez it will be seen, avoids these natural difficulties, by skirting the elevated ranges in place of crossing them, and yet makes a much more direct line between the terminal stations. The entire length of the new route is eighty-five miles.

Screw Cutting Machine. By Brown & Sharpe, Providence, R. I. We give below a drawing and description of a machine, which has now been in use in many of our best workshops for a sufficient time to establish its merit as a most efficient and valuable tool. Its quality as regards saving of labor and consequent economy, in comparison even with machines otherwise employed for similar work, appears from this, that one man with such an apparatus can

Fig. 1.



produce as many screws as from three to five can make, on as many engine lathes.

The bed, A, which is of cast iron, is very heavy, and has at one end two uprights cast solid with it, containing bronze boxes to support the spindle. The front box, B, is made in four parts, that it may be closed up to compensate for wear, the two middle pieces

being forced in horizontally towards the centre of the spindle by the screws on each side of the box. The spindle is of steel, and has only one flange or collar, which is outside of the front box. Between this flange and the end of the box is a hardened steel washer. The cone pulley, C, is kept from turning on the spindle by a spline. Back of the pulley is a nut by which it can be forced forward and its hub kept up to the rear end of the front box. By these devices, the front journal can readily be kept tight, though considerable wear should take place. Should the spindle heat by continued use, it will not bind end-wise, nor will its expansion length-wise affect the accuracy of the work done on the machine. The spindle is hollow, the hole being one and a quarter inches diameter, and has on the front end a steel chuck, with screws and jaws for adjusting and holding the iron bar or wire from which the screws are made. On the rear end of the spindle is a leading screw, and in the hand-lever, I, a section of a nut, which fits into this screw. The bar, H, is fitted to slide end-wise in bearings parallel to the spindle, and carries on its front end a tool-head, J, and to the rear end the lever, I, is attached. A screw thread can be cut with this device on a bar projecting from the chuck on the front end of the spindle, with a tool held in the head, J, on the front end of the bar, H. At the other end of the bed of the machine, resting upon two V-shaped ways, is a rectangular piece, D, which can be fastened at any point by two screws from underneath. Upon and attached to this is another piece, which is fitted to slide in a direction parallel to the bed, and is moved by the hand-wheel, K, connecting by means of a pinion and rack, or, for light work, by the hand-lever, E, substituted for the hand-wheel, K. On the end of this sliding piece, nearest the spindle, a round head, F, is so arranged as to revolve horizontally. In the edge of this head are seven holes, which serve to hold the mills, cutters, and dies used in making screws. The head is held very firmly in its place, while the cutters are operating by a steel pin, which comes up through the piece on which the revolving head rests, at the point nearest the line of the spindle. This pin is hardened and slides through a hardened steel bushing, and the upper end, which is tapered, enters into hardened bushings in the bottom of the revolving head. These steel bushings are ground inside and out, after hardening, and the pin is afterwards ground into them so that the point fits them all alike. When the revolving head is moved back, this pin is withdrawn by means of a short lever,

the fulcrum of which is attached to the sliding piece which supports the revolving head, one end being connected with the pin, and the other striking an inclined plane in the lower piece, D, which is fastened to the bed. The extreme back motion given to the sliding piece carrying the revolving head by the hand-wheel, K, brings a star wheel on the under side of the revolving head in contact with a dog, projecting upward from the lower piece, D, which causes the head to revolve far enough to bring the next tool in a position ready to operate on the screw. When the revolving head is brought forward, the star wheel slips over the dog, and the pin enters the hole in the head, being forced up by a spring acting on the rear end of the short lever, after which the tool commences to operate.

There is an arrangement whereby any wear in the centre hole of the revolving head can be compensated for, and there are two gibs, one on each side of the sliding piece, carrying the revolving head, to adjust its position or to close up for wear. At the outer end of the sliding piece, projecting underneath it, is a screw, L, which can be set to limit its motion. The tools in the revolving head are each held by two screws, by which they can be adjusted as required for the different cuts on the work. Shoes are inserted underneath these screws to prevent the tools they hold from being injured. Between the spindle and revolving head and attached to the bed, is a slide rest operated by a crank, M, attached to a screw, or for light work, by the hand-lever, G. It has two tool-posts, one at the back, sliding in a groove parallel with the ways of the machine, and one in front, sliding in either one of two grooves, side by side, but which are at right angles with the one at the back end. Both of these tool-posts can be raised or lowered to adjust the tools. The bottom piece of this rest is planed on the ways of the bed, and can be moved upon them to any position required. The tools in this rest may be used for cutting off, pointing, or grooving, and their movements may be limited by set nuts upon a screw underneath the rest. Oil is supplied from the can placed above the revolving head, to the cutting tools, when the machine is in operation. The machine is set upon an iron table, having a channel around the edge to catch the oil, which is conducted by tubes to a pail hung underneath the machine. The overhead work, which is shown in a reversed position on the floor in front of the machine, has two of Brown's patent friction pulleys, by which the motion of the spindle can be changed at will.

Standard Wire Gauge.—The importance of a uniformity in standards for all things which have any extended use, is a matter both so self-evident, and so frequently noticed of late years, that we consider any comment would be superfluous. The only open question is that of selecting a standard which shall have the merits of convenience, ease of construction and verification, and accordance, if possible, with the best usage.

These were some of the points discussed by the Committee of the Franklin Institute, who had in charge the question of a standard gauge for screws and nuts, and it is with reference to these, that we should consider any similar arrangement having regard to another standard of an article in general use.

At the last meeting of the Institute, some remarks were made on this subject, in connection with several instruments for measuring the thickness of wire and sheet metals manufactured by Messrs. Brown & Sharpe, of Providence, R. I., which were exhibited on the occasion. These gentlemen have arranged, and have caused to be already pretty largely adopted, a standard wire gauge, known as the "American gauge," which seems to fulfill in a very satisfactory manner the various requirements of the case.

No. of Wire Gauge.	New Standard: Size of each No. in dec. parts of an in.	New Standard: Diff. bet. cons. Nos. in dec. parts of an in.	Old Standard: Size of each No. in dec. parts of an in.	Old Standard: Diff. bet. cons. Nos. in dec. parts of an in.
0000	·460	....	·454	....
000	·40964	·05036	·425	·029
00	·36480	·04484	·380	·045
0	·32495	·03994	·340	·040
1	·28930	·03556	·300	·040
2	·25763	·03167	·284	·016
3	·22942	·02821	·259	·025
4	·20431	·02511	·238	·021
5	·18194	·02237	·220	·018
6	·16202	·01992	·203	·017
7	·14428	·01774	·180	023
8	·12849	·01579	·165	·015
9	·11443	·01406	·148	·017
10	10189	·01254	·134	·014
11	·09074	·01105	·120	·014
12	·08081	·00993	·109	.011
13	·07196	·00885	·095	·014
14	·06408	·00788	·083	·012
15	·05707	·00702	·072	·011
16	·05082	·00625	·065	·007
17	·04526	·00556	·058	·007
18	·0403	·00495	·049	·009
19	03589	·00441	·042	·007
20	·03196	·00393	·035	·007
21	·02846	·00350	032	·003
22	·02535	·00311	·028	·004
23	·02257	·00278	·025	·003
24	·0201	·00247	·022	·003
25	·0179	·00220	·020	·002
26	·01594	·00196	·018	·002
27	·01419	·00174	·016	·002
28	·01264	·00155	·014	·002
29	·01126	·00138	·013	·001
30	·01002	·00123	·012	·001
31	·00893	·00110	·010	·002
32	·00795	·00098	·009	·001
33	·00708	·00087	·008	·001
34	·0063	·00078	·007	·001
35	·00561	·00069	·005	·002
36	·005	·00061	.004	·001
37	·00445	·00056	....	....
38	·00396	·00049	....	....
39	·00353	·00043	....	....
40	·00314	·00039	....	....

In this scale, the starting point is taken at No. 36, which represents a diameter of ·005 of an inch, and this quantity being multiplied by ·0503536, gives the next size, or No. 35, and this product being again multiplied by the same factor, ·0503536, gives the next size, or No. 34, and so on for each successive size above, while the smaller sizes are obtained similarly by dividing ·005 of an inch, and the quotients obtained successively by this same number.

The accompanying table shows the numbers so obtained for the new scale, as compared with the sizes of the old one.

By this means it will be perceived that the sizes vary in a regular geometrical progression, which produces a very gradual change in size for the smaller diameters, but a rapidly increasing difference as the larger ones are reached. This is evidently, exactly what is demanded in practice.

Fig. 1.

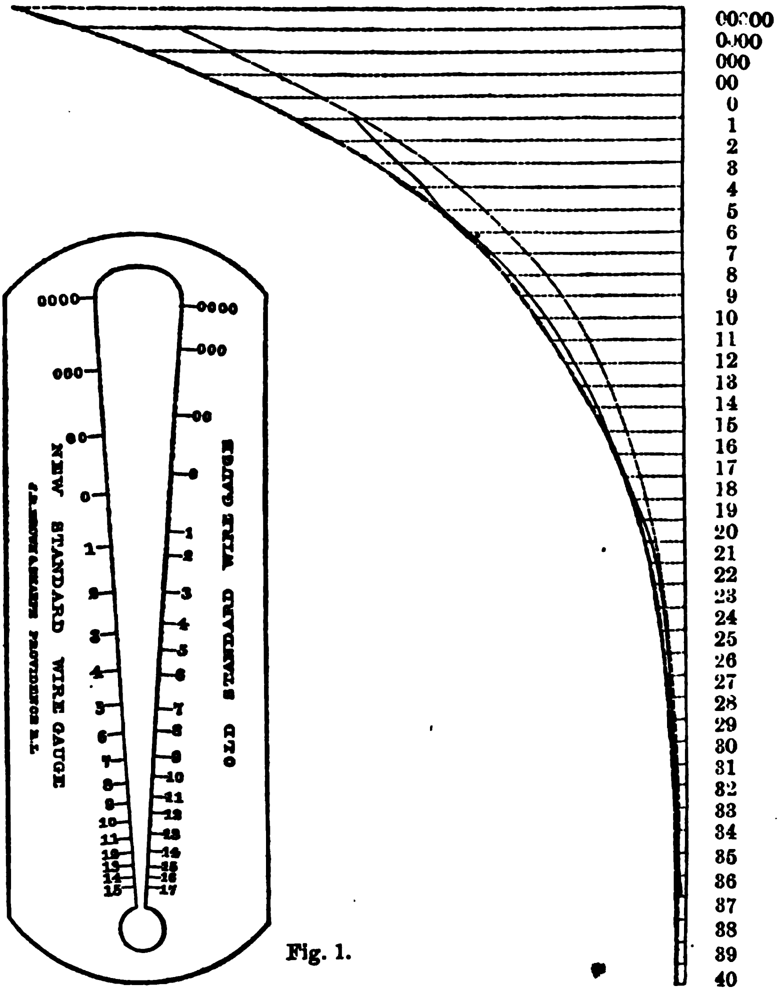


Fig. 1.

This relation is well exhibited by the graphical projection in Fig. 1, where the different numbers being indicated by the successive distances upon the vertical line, the relation of the correspond-

ing sizes is set off on the corresponding horizontal lines, and a line then struck through the terminal points. Thus, the light dotted line represents the result of this process for the Brown & Sharpe gauge; the heavy dotted line, that derived from a very similar gauge, proposed by Mr. Latimer Clark, and the very irregular full line, the state of relations in the common or Birmingham gauge, as given by Holtzapfell.

WEIGHT OF WIRE AND PLATES, AS PER AMERICAN GAUGE.

No. of Gauge.	Size of each No.	Weight of Wire, per 1000 Lineal Feet.				Weight of Plates, per Square Foot.			
		Wro't Iron.	Steel.	Cop'r.	Brass.	Wro't Iron.	Steel.	Cop'r.	Brass.
	Inch.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
0000	·46000	560·74	566·03	640·51	605·18	17·25	17·48	20·838	19·688
000	·40964	444·68	448·88	507·95	479·91	15·3615	15·5663	18·557	17·533
00	·36480	352·66	355·99	402·83	380·67	13·68	13·8624	16·525	15·613
0	·32486	279·67	282·30	319·45	301·82	12·1823	12·3447	14·716	13·904
1	·28930	221·79	223·89	253·34	239·35	10·8488	10·9934	13·105	12·382
2	·25763	175·89	177·55	200·91	189·82	9·6611	9·7899	11·671	11·027
3	·22942	139·48	140·80	159·32	150·52	8·6033	8·7180	10·393	9·8192
4	·20431	110·62	111·66	126·35	119·38	7·6616	7·7638	9·2552	8·7445
5	·18194	87·720	88·548	100·20	94·666	6·8228	6·9137	8·2419	7·787
6	·16202	69·565	70·221	79·462	75·075	6·0758	6·1568	7·3395	6·9345
7	·14428	55·165	55·685	63·013	59·545	5·4105	5·4826	6·5359	6·1752
8	·12849	43·751	44·164	49·976	47·219	4·8184	4·8826	5·8206	5·4994
9	·11443	34·699	35·026	39·636	37·437	4·2911	4·3483	5·1837	4·8976
10	·10189	27·512	27·772	31·426	29·687	3·8209	3·8718	4·6156	4·3609
11	·090742	21·820	22·026	24·924	23·549	3·4028	3·4482	4·1106	3·8838
12	·080808	17·304	17·468	19·766	18·676	3·0303	3·0707	3·6606	3·4586
13	·071961	13·722	13·851	15·674	14·809	2·6985	2·7345	3·2598	3·0799
14	·064084	10·886	10·989	12·435	11·746	2·4032	2·4352	2·9030	2·7428
15	·057068	8·631	8·712	9·859	9·315	2·1401	2·1686	2·5852	2·4425
16	·050820	6·845	6·909	7·819	7·587	1·9058	1·9312	2·3021	2·1751
17	·045257	5·427	5·478	6·199	5·857	1·6971	1·7198	2·0501	1·937
18	·040303	4·304	4·344	4·916	4·645	1·5114	1·5315	1·8257	1·725
19	·035890	3·413	3·445	3·899	3·684	1·3459	1·3638	1·6258	1·5361
20	·031961	2·708	2·734	3·094	2·920	1·1985	1·2145	1·4478	1·3679
21	·028462	2·147	2·167	2·452	2·317	1·0673	1·0816	1·2893	1·2182
22	·025347	1·703	1·719	1·945	1·838	·95051	·96319	1·1482	1·0849
23	·022571	1·350	1·363	1·542	1·457	·84641	·8577	1·0225	·96604
24	·020100	1·071	1·081	1·223	1·155	·75375	·7638	·91053	·86028
25	·017900	0·8491	0·8571	·9699	0·9163	·67125	·6802	·81087	·76612
26	·01594	0·6734	0·6797	·7692	0·7267	·59775	·60572	·72208	·68223
27	·014195	0·5340	0·5391	·6099	0·5763	·53231	·53941	·64303	·60755
28	·012641	0·4235	0·4275	·4837	0·4570	·47404	·48036	·57264	·54103
29	·011257	0·3358	0·3389	·3835	0·3624	·42214	·42777	·50994	·48180
30	·010025	0·2663	0·2688	·3042	0·2874	·37594	·38095	·45413	·42907
31	·008928	0·2113	0·2132	·2413	0·2280	·3348	·33926	·40444	·38212
32	·007950	0·1675	0·1691	·1913	·1808	·29813	·3021	·36014	·34026
33	·007080	0·1328	0·1341	·1517	·1434	·2655	·26904	·32072	·30302
34	·006304	0·1053	0·1063	·1204	·1137	·2364	·23955	·28557	·26981
35	·005614	·08366	·08445	·0956	·09015	·21053	·21333	·25431	·24028
36	·005000	·06625	·06687	·0757	·0715	·1875	·19	·2265	·2140
37	·004453	·05255	·05304	·06003	·05671	·16699	·16921	·20172	·19059
38	·003965	·04166	·04205	·04758	·04496	·14869	·15067	·17961	·1697
39	·003531	·03305	·03336	·03775	·03566	·13241	·13418	·15995	·15113
40	·003144	·02620	·02644	·02992	·02827	·1179	·11947	·14242	·13456
Specific Grav....		7·7747	7·847	8·880	8·386	7·200	7·296	8·696	8·218
Weight per Cubic Foot.........		485·874	90·45	554·968	524·16	450·	456·	543·6	513·6

The Specific Gravities to determine the weights, and the calculation of them, were taken and made by Charles H. Haswell, 6 Bowling Green, N. Y. Diameters and thickness determined by the American Gauge, which is introduced and manufactured by J. R. Brown & Sharpe, of Providence, R. I. This gauge is now very extensively adopted among manufacturers of wire and plates. It should be considered the standard American gauge. To be had in the principal hardware stores in the country.

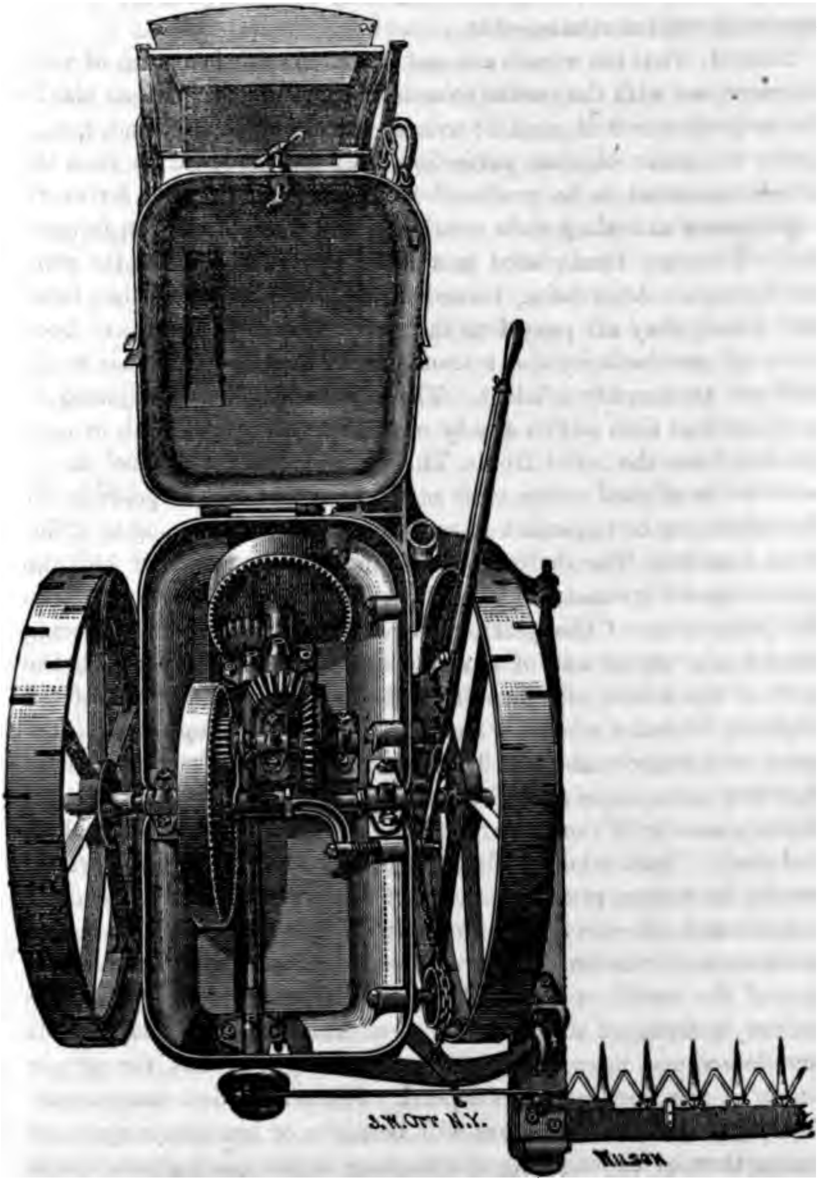
The great want of regularity in the common gauge, as compared with this new one, is also exhibited by Fig. 2, which shows one side of one of the many forms in which wire gauges are prepared by Messrs. Brown & Sharpe, and in which the numbers by both old and new gauges can be taken at once and compared.

The subjoined table, which has been prepared with great care, gives the weight of all sizes of wrought iron, steel, copper and brass wire and plates whose diameter or thickness has been determined by the American Gauge.

Harvesters.—To America belongs the honor of first successfully producing the mowing and reaping machines. When first introduced, although their form was awkward and cumbersome, yet their practical usefulness was fully demonstrated, and the inventive genius of our country has ever since been encouraged to persevere in efforts at improvements, adding one important feature after another, until the Harvesters of to-day are among the most perfect and satisfactory labor-saving machines of which the age can boast. The State of Ohio stands foremost in the field as a manufacturer of Harvesters, having a large capital invested in that branch of agricultural machinery.

To a person crossing the State, along the line of the Pittsburg, Fort Wayne and Chicago Railway, it is a source of surprise to notice, in passing the different towns, the large shops devoted exclusively to agricultural machinery. Of late years, the machinists of Ohio have devoted a great share of labor, time and money to perfecting the Harvesters, and in their shops we find the tools, the arrangements and appointments such as cannot be surpassed in any establishment in the country. A good example of such works is furnished by the shop of E. Ball & Company, Canton, Ohio; and some of the improvements introduced by this firm will, we think, be interesting to our readers. To Col. E. Ball, of Canton, Ohio, is conceded the honor of having produced the first successful two-wheeled Harvester ever built—the old *Ohio*—and several years were spent with constantly increasing resources and facilities in manufacturing and perfecting that justly popular machine. It soon became evident to the constructors that the mechanical standard of the Harvester must be elevated if it was to keep pace with the rapid march of improvements, which characterizes our day, and fully meet the constantly increasing tax upon its durable qualities. Each year's experience and observation rendered it more apparent

that however well made, the rough-cast Harvesters could not be built to meet their new conditions, and it was therefore determined



to produce a new machine upon wholly different principles, with the belief that the increasing intelligence, wealth and enterprise of

the country would insure the success of the undertaking. The *World's Harvester* is the result of that determination.

The features of this machine are first, That all parts of various machines are interchangeable.

Second. That the wheels are cast *blank*. As this is a point of vital moment, we wish the reader to note it particularly. These blanks are as perfect as it is possible to make a casting of any kind, but in order to secure *absolute* perfection, they are made larger than the wheels intended to be produced from them, to provide for every contingency attending their moulding, and the contraction in cooling. They are then placed in a lathe and turned off to the standard gauge. After being turned down to the required size, faced and bored, they are passed to the gear cutters. These have been invented and built by the manufacturers expressly for this work, and are thoroughly efficient. The blanks are firmly adjusted in position, and then with a steady measured stroke, the teeth or cogs are cut from the solid iron. The cutting of every wheel in the machine is effected in the same manner, so that it is impossible for the wheels to be imperfect in any respect, or for one cog to differ from another. The shafting of this machine is prepared with the same regard for exactness in all its relations, as that which marks the preparation of the gearing, each piece with its journals being turned to a gauge and of a size which when driven through the bore of the wheel, of which it is the axis, does not admit of the slightest vibration of either shaft or wheel. Although the adjustment of the shafts and the boxes of the several wheels is so firm that they seem to be a single piece, the connection is rendered additionally secure by the introduction of keys sunken into both wheel and shaft. Each wheel with its cogs, and shaft with its journals, having been thus prepared, the next important matter is to adjust them to each other in a frame which will preserve them in the exact positions and relations they are intended to occupy. The foundation of the *world's machine*, like that of all structures intended to endure, is arranged with especial care. The frame of a reaper is its *foundation*, and upon the solidity and strength of *this*, the proper action of the working parts depend. In moving over uneven surfaces, it is obvious that there will be more or less strain upon the frame, thereby endangering the bearings of the gearing attached to it. Heretofore, machines were built with light iron or heavy wooden frames, neither of which can entirely resist the strain to which they are subjected while the latter is exposed to the additional disadvan-

tages arising from expansion, contraction and warping, thereby seriously affecting its permanency, as well as that of the bearings, &c., and it is equally obvious that the slightest derangement of the lines of action, throws the whole gearing out of adjustment, and increases the friction.

To avoid these difficulties, the foundation of this machine consists of a *single piece of iron*, so shaped that there can be no strain or torsion in any direction, which is not fully provided for. This foundation or *case*, while it furnishes an unchangeable base for the gearing, answers the further purpose of entirely excluding water, dirt, grass, and indeed, everything else that is calculated to prove injurious to the machinery; since it has not only a seamless bottom, but also a closely fitting hinged top. The bearings of the machine are fixed with the greatest exactness, because, upon this depends an accurate operation of the gearing. First, a jig or skeleton, representing all the journals, is laid in the hold or frame, and the bearing filled with Babbitt metal. Three important ends are secured by this process. First, the *lines* of the machine are secured with great precision, the exact place for the centre of each journal is fixed, and thereby the relative position of each shaft and wheel is determined. Second, each one being adjusted by the same standard, all are precisely *alike*. Third, the Babbitt metal affords its usual good effects. The boxing is all "Babbitted," drilled and turned to a standard gauge. Not only are the holes bored and the bolts turned, so that the fit is perfect, but the threads of the bolts are cut upon a lathe, so that when forced into their place and secured with nuts faced in the same manner as the bolt-heads and bearings, there is not a possibility of lateral movement. The permanency of the boxing is further secured by the fact that each box is "stooled" or sunk into the "pillar-block," the connection being carefully bored and turned. Under each of these "stools," there are a number of tin washers, which can be removed one by one, as the wear of the metal may require.

With this arrangement for re-adjustment, it is possible to keep the journals, and hence the cogs of the wheels, in their proper relation to each other. Thus each of the several parts from the tin washer underlying the "stools," to the largest wheel or shaft, is perfect in form and adjustment, and enclosed in a neat iron case, in which it is perfectly secured from all external causes of destruction.

Mr. Boyle and the Zentmayer Lens.—We make, with great willingness, at the request of Mr. Boyle, the following explanations

with the view of avoiding a misunderstanding of our notice in the September number:—1st. The charges alluded to as "slanders" were made by the editor of *Humphrey's Journal* not by Mr. Boyle. 2d. The conclusion we draw from the facts stated in connection with the action of the New York Photographic Society is, that the whole affair was managed without the least care or attempt to reach the facts of the case. So, only, can we reconcile the report with the documentary evidence in our possession, and the drawings published by Mr. Boyle himself in his letter.

Hydraulic Lift Graving Dock for Bombay.—One of these docks, invented by Mr. Edwin Clark, is, as we learn from *Engineering*, about to be constructed in England and sent out to India, this form being specially fitted for the purpose, by reason of its economy in first cost and working expenses, and because it can be erected in a very short time, as compared with other forms. The dock will be formed of thirty-six cast iron columns, six feet six inches in diameter, placed in parallel rows ninety-four feet six inches apart, from centre to centre, eighteen columns being arranged equidistantly in each row.

The lower part of each column will be let into the ground to such a depth as may be necessary, in order to secure a good foundation, the height from the ground to the top of the columns being eighty-seven feet. The dock has been designed with a view to its being erected where there is an extreme depth of water at high tide of forty-eight feet six inches, and the columns will rise thirty-eight feet six inches above that level. The bottom of each column is filled in with concrete, to a height of about twelve feet above the ground level; on this is laid a seating of timber to receive the bed-plates of the hydraulic presses. Each column contains two hydraulic presses, having fourteen inch rams, with a stroke thirty-three feet six inches in length. The upper ends of the two rams are connected to a wrought-iron cross-head, from either end of which depend chains, connected at their lower extremity with the girders supporting the pontoon. The upper portion of the cast iron columns are of Tuscan character, and those in each row are connected at their tops by a platform carrying a traveller. There is also a platform twenty feet wide, just above high water line, surrounding the dock, excepting at its entrance end. For the purpose of enabling the pontoon to be canted in various directions, the columns are arranged in three groups, each group being capable of being worked independently of the other two; thus, the first nine columns

on each side form one group, and the other nine columns on either side form the other two groups respectively.

The pontoon rests upon iron trellis girders, ten feet eight inches deep and ninety-six feet three inches in extreme length. The top and bottom members of these girders are connected together; the struts, consisting each of two parallel flat bars braced together, and the ties of a number of thinner bars. The girders are arranged in pairs, connected together at their top flanges by cross bracing.

The pontoon is 380 feet long by eighty-five feet wide, and it rests upon balks of teak timber laid on the top of the girders. The extreme depth of the pontoon at its sides is nine feet eight inches, and it slopes down to a depth of six feet eight inches in the centre; the centre of the pontoon is thus made shallower than its outside, with a view to enabling it to be used for vessels of greater draught. A flap at the entrance of the pontoon, thirty feet wide, lets down for the admission of vessels, and is then closed up water-tight against india-rubber, bringing the height of the entire end straight on a level with the sides. The pontoon consists of a frame work formed by three longitudinal box girders extending its whole length, in addition to the outsides, and these are connected transversely by forty-nine cross girders, the whole being covered with plates half inch thick. It is also divided internally into thirty-six water-tight compartments, each provided with a separate valve, so that it can be filled with water, if required, to prevent the straining of the pontoon by unequal loading.

The whole iron work in this fine structure will weigh about 7,000 tons, of which the pontoon alone takes 1,500 tons. For the convenience of shipment it has been found necessary to limit the weight of each piece of the structure, and the pontoon will have to be completed by riveting the parts together on their arrival at Bombay.

The engines for working the hydraulic rams will consist of two pairs of high-pressure horizontal cylinders, each twenty-two inches in diameter, with a two feet six inch stroke. These engines will work twenty-four pumps, having the same length of stroke, and with plungers two and a quarter inches in diameter. These engines will be capable of lifting the Bellerophon, on a suitable pontoon, thirty-three feet high in less than an hour, the total weight of that ship and its pontoon being, together, equal to about 11,000 tons.

Structure of the Sun.—Some points of interest and novelty in connection with the above subject, appear in two articles which we have just received in the last published number of the *Proceedings*

of the Royal Institute, No. 46. These articles are first, "On the Sun as a variable star." By Mr. Balfour Stewart, and second "On the Chemistry of the Primeval Earth." By Mr. T. Sterry Hunt.

The first author, after a preliminary discussion, and disposal of the various unsatisfactory hypotheses which have been suggested in explanation of the phenomena of variable stars and periodicity in sun spots, proceeds to enunciate, in a concise form, a theory not unfamiliar in many points but now most completely expressed.

The photosphere or visible surface of the sun, is conceived, as in most modern theories, to consist of cloud masses, or to be a surface of condensation terminating the ascending currents of vapor which are constantly rising from the central mass. The faculæ or portions of superior brightness often observed and frequently accompanying sun spots, are portions of this cloudy matter which have reached an excessive height in the solar atmosphere and thus escape the absorbing or light-obscuring influence of that medium.

The fact that these facula as a rule predominate on the following side of a spot, indicates to us that they have been projected from a lower to a higher region, and thus, by reason of their slower motion, fall behind in the more distant and therefore more rapidly moving regions into which they have been projected, exactly on the same principle which explains the westerly motion of our trade winds.

On the other hand, as shown by the observations of Carrington, sun spots have a forward motion with reference to the adjacent regions of the surface, thus indicating that the influence producing them has descended from a higher and more rapidly moving region, This influence Mr. Stewart supposes to be a down-rush of the colder and absorbtive atmosphere which follows the explosion or uprush by which the faculæ were projected outwards.

Such being the nature of sun spots, the cause of the periodicity is next examined, and it is shown, from the observations of Messrs. De la Rue, Stewart and Loewry, which we have before noticed, that the period of ten years, now well established, depends upon the influence of the two planets, Venus and Jupiter; the one being effective by reason of its nearness, and the second by its mass.

As a complement and conclusion to this description, we may well insert the substance of Mr. Hunt's paper, where he speaks of the solar constitution.

After drawing attention to the facts demonstrated recently by Deville, as regards the decomposition of the most fixed chemical compounds by a very high temperature, he proceeds as follows:

"The sun, then, is to be conceived as an immense mass of intensely heated gaseous and dissociated matter, so condensed, however, that, notwithstanding its excessive temperature, it has a specific gravity not much below that of water; probably offering a condition analogous to that which Cagniard de la Tour observed for volatile bodies when submitted to great pressure at temperatures much above their boiling point. The radiation of heat, going on from the surface of such an intensely heated mass of uncombined gases, will produce a superficial cooling, which will permit the combination of certain elements and the production of solid or liquid particles, which, suspended in the still dissociated vapors, become intensely luminous and form the solar photosphere. The condensed particles, carried down into the intensely heated mass, meet with a heat of dissociation; so that the process of combination at the surface is incessantly renewed, while the heat of the sun may be supposed to be maintained by the slow condensation of its mass; a dimunition by $\frac{1}{1000}$ of its present diameter being sufficient, according to Helmholtz, to maintain the present supply of heat for 21,000 years."

This hypothesis is due, as our author remarks, to Faye, and seems to accord best with our present knowledge. It is especially worthy of note that it accords with the observed fact, that the intensity of the sun's emitted rays corresponds with those derived from chemical combination, while other considerations would lead us to assign the primary source of the solar temperature to a much more intense origin, such as the heat developed by impact of meteoric matter, a source omitted, but not excluded, in the above hypothesis.

Photograph of Invisible Light.—We have just received, through the kindness of a friend, a photograph of the actinic portion of the solar spectrum, showing the absorption bands (as well of course as the intermediate luminous spaces), from G to R, of which all beyond H are invisible. This picture is made by the use of lenses and prisms of quartz, as glass, even of the thinnest kind, entirely obstructs these rays. It was prepared as one of the illustrations for the new edition of Miller's Physics (the German copy) and may be there found.

In Becquerel's last book, just published, "La Lumiere," admirable copies of this photograph will be found in both volumes. It is engraved on steel, and being printed with a dark brown ink, is hardly distinguishable from the original.

The difficulty of producing such a photograph is very great, and certain imperfections seem as yet inseparable from the result. Thus,

as we have mentioned, all the apparatus through which the light passes is of quartz; but quartz is a double refracting medium; hence, even if we so cut the prisms and lenses from the crystal as to reduce the disturbance from this cause to a minimum, it will still exist and produce a notable effect.

Prof. William A. Miller, of London, made a very thorough investigation of the "photographic transparency of bodies," in the hope of finding something which could be substituted for quartz with advantage in this respect, but without success.

It is for the reason above noticed, we presume, that this actinic spectrum is deficient in the perfect definition of lines, which characterises the spectrum of the visible and actinic rays, produced by Mr. L. M. Rutherfurd, of which we have also a copy before us.

This photograph is forty-one and a half inches in length, and shows the part of the spectrum from the beginning of the blue (the green being absolutely devoid of photographic power, as has been demonstrated by Mr. Rutherfurd), up through indigo and violet to the limit of visibility, and of the rays which will traverse glass.

The sharpness of definition and fineness of lines in all parts of this spectrum is so great, that nothing more could be appreciated by the eye without the aid of a lens.

Comparing this with the German spectrum, we find that the space in the latter between the lines G and H measures about seven-eighths of an inch, and shows about thirty-one lines, while in that of Mr. Rutherfurd, it measures sixteen inches, and shows at least 600 lines. This greater expansion is of course due to the use of a greater number of prisms, but if attempted with those of quartz, would introduce such errors as to obliterate in all probability all the existing lines.

Tidal Rainfall.—In a recent communication to the American Philosophical Society, Mr. P. E. Chase discussed the rainfall of Philadelphia, with special reference to the position of the moon. His examination of forty-three and a half years' records at Pennsylvania Hospital, five years at Girard College, and seventeen years by Prof. Kirkpatrick, leads him to the conclusion that quadrature, apogee, south latitude and declination, horizontal attraction, and action in the minimum pressure-plane of the daily barometric ellipsoid, are each accompanied by a tendency to increase of rain and fall of barometer,—while syzygy, perigee, north latitude and declination, meridional attraction, and action in the plane of maximum pressure, tend to produce fair weather and a rise of barometer. He also finds that these tendencies, like the ocean tides, are more marked in low, than in high latitudes.

Civil and Mechanical Engineering.

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

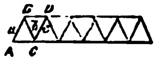
By G. S. Morison, C. E.

(Continued from page 237.)

Strains in the Chords (Bending Strains.)

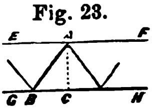
As the chords of a beam truss are at right angles to the direction in which the weight acts, the strains in them must be produced solely by the distributing action of the web, each member in turn producing its effect. Thus, in Fig. 22, the strut *a* imparts a strain to the lower chord at the point A, and to the upper chord at B, the tie *b* imparts a further strain at B and at C, the strut *c* at C and D, &c.

Fig. 22.



In Fig. 23, let E F and G H represent the two chords, and A B an inclined member of the web, B C being the amount of its inclination, and A C the depth of the truss. The strain in A B will be equal to the shearing strain at this point multiplied by A B and divided by A C, and the horizontal component of the forces acting in A B equal to the shearing strain multiplied by B C and divided by A C. This horizontal component is thrown entirely upon the chords, and hence the force applied to either chord by a member of the web is equal to the shearing strain at that point multiplied by the inclination of that member, and divided by the depth of the truss. While the shearing strain is positive, the forces thus thrown upon the upper chord act towards the right, and those thrown upon the lower chord, towards the left; when the shearing strains become negative, these directions are reversed. In each chord, the forces acting in opposite directions, balance one another; in the upper chord they act towards each other and create a compression which increases from each end to the point where the shearing strain changes its sign; in the lower chord they act from each other, and produce a tension of like intensity.

Fig. 23.

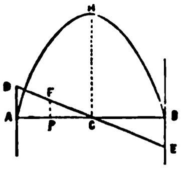


The strains in the chords increase at each point where an inclined member of the web terminates, but to simplify the investigation of the law of this increase, it may be considered gradual (as in a solid

beam), the inclination of the brace then disappearing as a factor in the rate of increase. The increment of the strain in the chords at each point is then equal to the shearing strain divided by the depth of truss; and the strain in the chords is everywhere equal to the sum of the shearing strains between that point and the end of the truss divided by the depth.

When a beam is uniformly loaded, the chord strains will increase with an uniformly decreasing increment from the end to the centre, and decrease similarly to the further end; the strains being everywhere proportional to the ordinates of a parabola. In Fig. 24, let D E be the line denoting the shearing strains in the uniformly loaded beam, A B. The chord strain at any point, P, is equal to the sum of the shearing strains between A and P, represented by the area of the trapezoid A D F P, divided by h, the depth of truss. Adopting the notation already used—

Fig. 24.



$$\text{A P} = \tfrac{1}{2}\, l - x,\ \text{A D} = \frac{wl}{2},\ \text{P F} = wx$$

$$\text{area A D F P} = \tfrac{1}{2}\left(\frac{wl}{2} + wx\right)\left(\tfrac{1}{2}\, l - x\right) = \frac{l^2 - 4x^2}{8}\, w$$

and the chord strains throughout the beam are the ordinates of the parabola whose equation is—

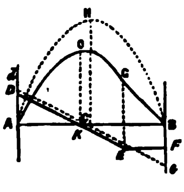
$$y = \frac{l^2 - 4x^2}{8h}\, w$$

When $x = \pm \tfrac{1}{2}\, l$, $y = o$, and when $x = o$ (centre of beam), $y = \dfrac{l^2 w}{8h}$

Making C H $= \dfrac{l^2 w}{8h}$, A H B, having its vertex at H, will be this parabola.

In the case of a beam partially loaded, the beam itself being supposed without weight, the chord strains in the loaded portion will be denoted by the ordinates of a parabola having its vertex over the point where the sign of the bearing strain changes, and in the unloaded portion by an inclined straight line (Fig. 25). As the curvature of the parabola, is determined by the inclination of the line D E, parallel to the line de, which denotes the shearing strain in the beam, A B, when uniformly loaded, this parabola has the same parameter as the parabola A O B which corresponds to the uniform load.

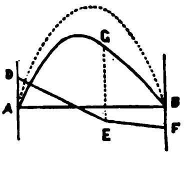
Fig. 25.



When a beam is loaded throughout, but more heavily in one part

than another, the chord strains will be denoted by parts of two parabolas, the parameters of which are determined by the intensities of the two loads (Fig. 26.)

Fig. 26.



A parabola passing through the points A and B, and having the central line C H for its axis, necessarily includes any similar parabola passing through either A or B, but having another line, as K O (Fig. 25), for its axis. This appears at once from the figures. It follows that the strains in the chords are everywhere greater when the beam is fully loaded than under any possible partial load, and an investigation of the effects of a full load includes all maximum strains. The same is shown by Plate 1, Fig. 11, where it is evident that the sum of the shearing strains between any point and one end of the beam is greatest when the whole beam is covered by the advancing load.

Reduction of the Strains in the Chords.

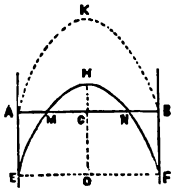
As the chord strains are inversely proportional to the depth of truss, the first step in reducing them is to increase this depth. Such an increase, however, is practicable only to a limited extent, a depth of more than one-eighth the length being seldom possible in long spans. The amount of material in the web increases but slightly with the depth (the entire increase being in the compression members) so long as the angular inclination of the braces remains unchanged, but when the depth is increased without changing this angle, the length of panel is also increased, and it becomes necessary either to sustain the road-way by independent trussing across the panels, or to increase the number of systems, thereby multiplying the details; either of which arrangements is more or less expensive and objectionable. But in a long span the chief limit to the depth is that imposed by the necessary requirements for stability against wind, which forbid the use of a depth too great in proportion to the breadth of base. The safe relative depth differs materially with the character of the bridge; it is greater in a through bridge than in a deck bridge, whose piers extend only to the bottom chord; greater still in a deck bridge, in which the piers are carried to the upper chord; while probably the arrangement which admits of the greatest depth is that in which the bridge is hung from points half way between the top and bottom, a plan adopted in the bridge at Mayence, across the Rhine, a double parabolic truss having a depth equal to more than three times the breadth of base.

In the cases of free beams already examined, the top chord is strained only in compression, and the bottom chord only in tension. If a tension could be imparted to the top chord, independently of the compression caused by the load, this tension would have to be overcome before any compression could exist; a like result would ensue if a similar independent compression were given to the bottom chord, the resulting strains in each case being at every point the difference between that caused by the load, and that existing independently of it.

The existence of tension in the upper chord, and compression in the lower, is the reverse of the effect of weight upon a free beam, and will tend to bend the beam in an opposite way. The two bending strains are properly distinguished by the use of opposite signs, the plus sign denoting compression above and tension below, and the minus sign the reverse.

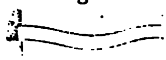
In Fig. 27, the beam A B is supposed to be subjected throughout to an uniform negative bending strain, equal to A E; if a load be now placed upon this beam which would produce in a free beam the positive bending strains denoted by the parabola A K B, the resulting strains will be given by the parabola, E H F. They will be positive between M and N, but negative from A to M, and from N to B; the strain at the centre is reduced from C K to C H, and the total amount of strains is represented by three small areas, A E M, M H N, and N B F, instead of by the large parabola, A K B. As in this case, the curvature is twice reversed, the bent beam will now resemble that shown in Fig. 28.

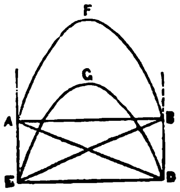
Fig. 27.



There are many obvious difficulties in the way of straining the chords independently of the action of the load, but if the ends of a beam were so secured as to be immovable, it is obvious that when the beam was loaded it would bend as shown in Fig. 28, and that as the effects are similar, the strains must be similar to those denoted by the resultant parabola, E H F (Fig. 27).* As in this case, the ends of the

Fig. 28.





* The load may be regarded as producing the usual positive strains, while the uniform negative strains are due to the reaction of the fastenings which hold the ends of the beam. The reaction of the fastening at A, produces the negative strains indicated by the triangle A B E, and that at A B, the negative strains denoted by B A D, the sum of the two being the rectangle, A B E D. Adding thereto the positive parabola, A F B, the resultant parabola, D G E, is obtained.

chords cannot move, the elongation in each chord due to tension would be exactly balanced by the opposite effect of compression, and the sum of the negative strains be equal in amount to the positive. Hence (Fig. 27), the areas—

$$\text{A M E} + \text{N B F} = \text{M H N}$$

or adding E M N F to both sides

$$\text{A B F E} = \text{E M H N F} = \text{A K B}$$

and substituting the value of these areas—

$$\text{A E} \times l = \tfrac{2}{3} l \times \frac{l^2 w}{8h} = \frac{l^3 w}{12h}$$

reducing we have—

$$\text{A E} = -\frac{l^2 w}{12h} \qquad \text{C H} = \text{C K} - \text{E A} = \frac{l^2 w}{24h}$$

The maximum strain is thus reduced to two-thirds the former amount, and the strain at the centre to one-third of what it was in a free beam. The equation of the parabola, E H F will be—

$$y = \frac{l^2 - 12x^2}{24h} w$$

which gives for M and N the points of reversal—

$$y = o \qquad x = \frac{l}{\sqrt{12}} = +\cdot 2887\, l$$

The total amount of the chord strain is reduced from—

$$\frac{l^3 w}{12h} \text{ to } \frac{l^3 w}{18h\sqrt{3}}$$

or to ·3849 of its former amount, a reduction of over sixty per cent. The saving of materials, however, in a truss with chords of variable section, will not quite equal this amount, as a considerable section of chord must be placed about the points of reversal, both to give continuity to the chords, and to provide against the variations caused by moving loads.

The strength of floor beams and door caps in buildings is greatly increased by building their ends into the walls, while every one knows how much the stiffness of a thin plank is increased by simply nailing down the ends; but in trusses of considerable length, it is difficult to take advantage of this source of economy. Sometimes it may be possible to anchor the ends of a wooden truss, as in the case of a deck bridge of a single span across a rocky chasm; a simple plan, however, is that adopted in a bridge over the little river Ciron, on the southern railway of France, a representation of

which is given in Figs. 29 and 30. This bridge, built to carry a double track railway, has a span of 98·43 feet in the clear, and is composed of three plate girders, the two outer ones being each 4·59 deep, and the intermediate one 6·56 feet. Fig. 29 is a general view of the bridge, while the details of the method by which the ends are made immovable, are shown in Fig. 30. The ends of the girders are formed with a square return downwards, and let into small apertures in the abutments (shown in elevation and in plan in Fig. 30); this return is fastened by bolts to the plate, *a a*, which bears against the face of the abutment. The effect of a weight upon the bridge, acting through the bent lever of the return, is to force the foot of the return towards the abutment, and confine the ends of the girder by the bearing of the plate against the masonry, the natural upward motion of the ends of the girder being thus ingeniously changed to a horizontal motion, which is more easily resisted.

Fig. 29.

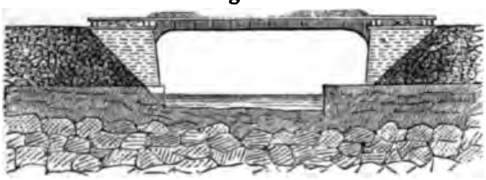
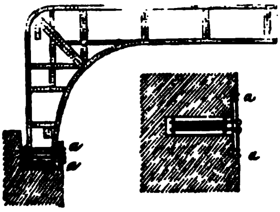


Fig. 30.



This bridge is remarkable for its lightness, and has been much admired, but there is no provision made for changes of temperature, and it cannot be regarded as a complete success. In fact, the difficulties which attend any method of fastening the ends of a truss become insuperable in metallic structures of large size, but in a bridge of several spans, much of the advantage of immovable ends with little of the disadvantage, is obtained by making the same truss continuous through the whole length of the bridge.

(To be continued.)

Water-Proof Paper, which may be used with excellent effect in packing goods which are likely to be exposed to damp or rain, may be prepared by treating strong unglazed paper with a mixture of equal parts copal varnish and linseed oil, with a little litharge to promote drying. The paper may either be painted alternately on either side with this mixture, or better, be immersed in a shallow pan containing it and drawn out over a wire stretched across near one end.

THE MISSISSIPPI BRIDGE.*

No engineering work at present in progress, either in Europe or in India, can pretend to exceed in interest the noble steel arched viaduct designed, and already commenced, by Mr. James B. Eads, the Chief Engineer of the Illinois and St. Louis Bridge Company. The able and exhaustive report which we have been enabled, through the courtesy of Mr. Eads, to lay before our readers will qualify them to form their own estimate of the difficulties to be surmounted; and the detailed engravings, which we shall shortly publish, will prove to them how carefully the various conflicting conditions have been balanced, and how conscientiously the several details have been worked out, so as to secure the highest practicable degree of economy consistent with the due stability of the works.

In the development of his design, Mr. Eads wisely commenced by making the stability of his piers indisputable. At the point of crossing, the true bed of the river, of limestone rock, is overlaid with a deposit of sand, varying in thickness from fifteen feet to about one hundred feet. There was ample evidence to prove that this deposit was scoured out to a great depth in times of flood, hence, to ensure the certain stability of the piers, but one course was open, namely, to carry them down to the rock itself. The ingenious method by which this is proposed to be accomplished will be found detailed in the report already published.

The massiveness of piers dictated by this condition, involving a height of some two hundred feet from base to summit, subject to the pressure of accumulated ice and great velocity of current, naturally suggested the adoption of an arched superstructure, since much less material would be required in such form of bridge than in any ordinary girder, whilst at the same time, in this instance, no extra expense would be incurred in the piers. At this stage, therefore, the problem resolved itself into the determination of the most economical form of arched superstructure.

In a long span-bridge, the weight of the structure itself is necessarily a large proportion of the gross load, and a very little consid eration will show that from this condition it follows that to secure the highest degree of economy, it will be necessary to employ in the construction the strongest material available for the purpose The advantage thus gained is much greater than that indicated by

* *Engineering*, Sept. 25th.

the absolute strength of the several materials. Thus, if the strain due to the weight of the structure itself be two and a half tons per square inch, whilst the limiting strain is fixed at five tons, there will be only two and a half tons per square inch, available for carrying the useful load—that is to say, if we calculate the strain on any member, independently of the weight of the structure itself, we must divide by two and a half tons for the area in square inches. If, on the other hand, the limiting strain be twelve and a half tons per square inch, there will be ten tons per square inch available for the useful load, hence, the sectional areas will be one-fourth of the former amounts, although the material in the latter instance is only two and a half times as strong as before. The economy resulting from the employment of the stronger material would, of course, be still greater in cases when the strain from the structure itself is a greater proportion of the gross amount.

The first step taken by Mr. Eads was, therefore, to obtain the strongest steel for his work; and for the sake of economy, he proposes at present rolling his steel bars of a wedge form, and fitting them together in a nine-inch lap welded tube, by which they would be held together as the staves of a barrel are held by the hoops. This arrangement is, however, subject to modification, and should any deficiency of strength be exhibited in the tubes thus built up, when under test in the 1,500 ton machine now being built for that purpose, we may be sure they will not be introduced into the bridge itself.

Given the form of bridge, the load, and the material, a very important and laborious portion of the work, the determination of the sectional areas of the different members had to be entered upon. We are told by Mr. Eads that several months of patient labor were spent by Colonel Flad and Mr. Pfeifer, in the investigation of the various problems involved; and certainly the exhaustive nature of their report, which even in its compressed form fills some eighty pages with closely printed formulæ and computations, exclusive of numerous complicated diagrams, proves that no considerations of personal labor were allowed to interfere with the important work confided to them, of determining, with the highest attainable degree of mathematical accuracy, the requisite proportions of the several members of the Mississippi bridge. The final result deduced was to the effect that each arched rib, of which there are four in the width of the bridge, loaded each with one ton dead, and ·8 ton

rolling load, required a sectional area of 144 square inches between points about twenty feet from each abutment. For these twenty feet end pieces of the ribs, the sectional area required to be one-half greater, or 216 square inches.

We are enabled to test roughly these results of the rigid application of mathematical reasoning by applying the formulæ advanced in a paper on wrought iron arches and viaducts, by B. B., given in an early number of (*Engineering*, Vol. I., page 306.) We have the following data:—

W = total load distributed = 515 feet × 1·8 tons = 927 tons.

r = ratio of span to rise = 10.

d = " " to depth of rib = 64.

t = compressive strain per square inch = 12·5 tons.

w = ratio of total load to rolling load = 2·25 tons.

Then the area of the rib, if of uniform section, will never be less than $\frac{Wr}{8t}\sqrt{1+\frac{16}{r^2}} = 101$ square inches. With an arched rib fixed at the ends, as this one is, the preceding area will have to be multiplied by the factor $\dfrac{\frac{d}{5r}+\frac{3}{4}+w-1}{w} = 1{\cdot}47$ for the area at the springing, assuming the temperature to be constant; and for the area at the centre, under the same conditions, we may take the mean of the two already computed. Hence, at springing, the area would be $101 \times 1{\cdot}47 = 149$ square inches; and at centre $\frac{101+149}{2} = 125$ square inches.

The range of temperature in the case of the Mississippi bridge being more than double that assumed in the paper, from which these formulæ are extracted, the expression for the influence of temperature at the centre of the arched rib will become $\dfrac{t}{t-\frac{37r}{4d}} = 1{\cdot}14$. At the springing, the value will, as stated in the paper, be one and a quarter times that amount = 1·43. Hence, the final areas, to include all strains from changes of temperature as well as rolling loads, will be:

At centre, 125 × 1·14 = 143 square inches.

At springing, 149 × 1·43 = 213 square inches.

These areas are, curiously enough, in each instance little more

than a square inch below those deduced from the elaborate investigations of the American engineers.

In one respect, however, the Mississippi bridge differs essentially from the ordinary run of arched bridges, for which the preceding general formulæ was designed. Usually the spandril filling, even if arranged vertical only, possesses sufficient inherent stiffness, by virtue of the rigidity of its connections with the arched rib and horizontal girder, to assist materially in preventing any distortion of that member when under strain. In the instance of the Mississippi bridge the spandril verticals are positively hinged, so that not the slightest incidental support is afforded by them to the arched rib, the stability of which is, consequently, since there is no horizontal girder, governed entirely by the self-contained diagonal bracing.

In fact, the essential part of the bridge is a curved rectangular beam, eight feet by forty-four feet, the former dimension being the vertical depth of the bracing, and the other one the distance apart of the face ribs, which are firmly tied together by horizontal bracing. There can be no question as to the lateral stability of the structure, but the depth of vertical bracing is so small in comparison to the span—eight feet to five hundred and fifteen feet—that it is absolutely necessary to consider the question of stability in that direction. Now, there must obviously be some limit below which the depth of the arched rib could not be reduced, even if the load were always uniformly distributed, and the mathematical position of the centre of pressure corresponded with the centre line of the rib. Thus, if the rib were but six inches deep, it could no more maintain its form, for an instant, than it would if built of ropes. Why a depth of eight feet should be assumed, as it is in the calculations, to afford perfect immunity from all disturbing forces, we are at a loss to guess.

It appears to us that an arched rib, *per se*, is neither more nor less than a long column, and that it should, consequently, be treated as such. In a long column of uniform cross section, subject to two equal and opposite end forces acting at the centre of gravity of the cross section, the unit strain would, mathematically, be uniform throughout the entire column. Experiment proves, however, that in consequence of variations in the elasticity of the material, the strain is in reality very unequally distributed over the cross sections; so much so, that in columns of certain length positive ten-

sion is induced by a compressive force. Now, how it is that in calculations concerning arched ribs, or, in other words, curved columns, the unit strain should be assumed uniform if the mathematical position of the centre of pressure at any point corresponds with that of the centre of gravity of the cross section at the same point, whilst in a straight column, under similar conditions, it is shown by experiment to differ so widely from it, is not to us apparent.

In the Mississippi bridge, the least dimension of the column is about one-sixty-fourth of the length; but on account of the curvature of that member, it is in effect, to a certain extent, supported at the centre of its length; hence, the equivalent ratio will be greater than the preceding fraction. We have not investigated the question minutely, but theory appears to indicate that the equivalent ratio would be $\frac{1}{64} \times \sqrt{2} = \frac{1}{45}$th of the length. If this be so, the elastic resistance of the steel to be employed in the bridge should have been deduced from that of a bar forty-five inches long by one inch in diameter, instead of from that of a bar twelve inches long only, as appears to have been done. We know of no experiments on steel columns of the former ratio, except some recent ones by Kirkaldy, the results of which may not yet be published, but there are any number of experiments on similar wrought iron columns on record, and in no instance do we remember the breaking strain of either a solid or hollow column being greater than twelve and a half tons per square inch, or about one-half only the resistance a short column of the same material would offer. In a steel column the loss of resistance would probably be smaller in proportion, but it would unquestionably be far too serious in amount to be neglected in the computations of the strength of the Mississippi bridge. We do not mean to assert that, even if the maximum strain were twenty-five per cent. greater than stated in the report, the bridge would not still be perfectly safe and serviceable; but, at the same time, we cannot account for the omission of this important element in calculations so refined as those instituted for the determination of the strains on that structure.

We cannot endorse all the statements advanced in the report as to the superior economy of employing iron or steel in compression. In fact, if the reasoning were sound, it would follow that the resistance of a cylindrical boiler flue to collapse would be greater than its resistance to a bursting pressure. It is well known, however,

that even an approximation to this condition would, in practice, be attended with fatal results. The radius of the arched rib of the bridge we are considering is about eighty-four times its depth, so, within certain limits, it may be considered as placed under similar conditions to a cylindrical flue, seven feet diameter, constructed of half inch steel plates, and subject to external pressure. The increased resistance which such a tube would offer, if properly stiffened by diaphragms, is well known to practical men, and precisely analogous support would be afforded to the arched rib if the spandrils were properly braced. Neglecting the element of the long column, the present arrangements would probably be the most economical; but if we include that in the consideration, it will be found that the increased strains from expansion, contraction, and deflection, due to the bracing of the spandrils, will be more than counterbalanced by the increased resistance the arched rib could offer to compressive strains, whilst, at the same time, the structure would be far less liable to vibration.

We have criticised thus freely the design for the Mississippi bridge, because we are sure that its originators have nothing to fear, and desire nothing more than a perfect ventilation of the subject. The entire process of reasoning by which their conclusions have been arrived at has been laid by them before their European brethren, whose criticism is thus boldly challenged. So much talent and perseverance has been already evinced that we are confident no one could hope to find the carrying out of this important work in more able hands. We still think that a somewhat cheaper and more easily erected bridge might be designed on the cantilever and central girder system, known as Sedley's; but, at the same time, no one can doubt that the structure, as designed, would form one of the noblest monuments of the engineering skill of the nineteenth century.

PERMANENT WAY.

Although the Permanent Way Company—of which nothing, we believe, has been heard since the death of Mr. Charles May, in 1860—was often disparaged as a jobbing speculation of railway engineers, it really did do something for the good of the so-called permanent way itself. This company—a very limited company in

* *Engineering*, Oct. 2d.

point of numbers—knew how to exercise a powerful agency for agitation in the right quarters; it greatly promoted the general adoption of the fish-joint, and it greatly stimulated that kind of permanent way scheming, called "invention," both among the company's own shareholders and among envious outsiders, ambitious of the possession of profitable patents of their own. *Requiescat in pace.*

The importance of a further improvement of the permanent way of railways is too great and too apparent to be disputed. It cannot, perhaps, be effected by a "company" of engineers or others—possibly not even by the powerful aid of profitable patents. We are not sure whether there is such a thing as patent earthworks, patent drainage, and patent ballasting. Whatever the way may be, its bed must be upon mother earth, and as our engineers make this bed so must lie their works. Cannot somebody patent something, and thus be able to push his invention, which shall prevent this bed from becoming so quickly tumbled under the unquiet rest of the seven sleepers (to each length of rail), sleepers whose rest should be lifelong, despite the thundering of expresses, mails, "ordinaries," "ways," goods, and minerals, over their much enduring necks and shins? Patent or no patent, our permanent way must have better bed and bedding, neither saturated with water nor pulverulent in dust; a bed like the operating table of an hospital, where all motion is well nigh impossible.

> Oh, bed! bed! bed! delicious bed!
> That heaven upon earth to the weary head,
> Whether lofty or low its condition!

and whether the weary-headed rail be of steel or iron, double or single-headed, or 5½ in. or 3¾ in. "in condition" of loftiness or abasement.

Until we have much better earthworks, which, like the foundations of a house, can lie still and support in perfect rest almost any load brought upon them, we can never have mathematically perfect railways, and until we have these we must tolerate that needless and extravagant increase of resistances which attends any increase of speed above the lowest rate of motion—an increase from 10 lb. or so per ton at very slow speeds on a level, to 30 lb. or 40 lb. at 60 miles an hour. It is idle to say that we can have no better earthworks than we now have, or that the permanent way can rest no

more quietly than it now does even on the best earthworks. The great bed of *wear* (and of *tear* as well) should be, and might be, almost as smooth as a billiard table, or at any rate as smooth as the best macadam roads in the days when stage coaching was in its superlative glory.

With the best earthwork and ballasting there must be abundant bearing surface of the rails on the sleepers, and of the sleepers on the ballast. Every permanent way engineer knows that the bearing surface is now insufficient to prevent the rails from notching upon the chairs, the chairs from bedding themselves in the sleepers—sometimes half way through—and the sleepers from churning the ballast. Mr. Fowler has long since abandoned the double headed rail, with its costly accessories of chairs, keys, and treenails, and adopted a Vignoles rail with a base nearly 6½ in. wide, which is fastened to the sleepers by screw bolts. Nothing but a rail of such proportions would ever stand the tremendous wear of the Metropolitan Railway traffic, and nothing but flat-footed rails, with bottom flanges as wide as can be rolled, say, up to 9 in., supported on sleepers a foot wide, 8 in. thick, and only 2 feet 3 in. apart centres, will suffice for the heaviest traffic soon likely to come upon our first class railways. Thicker sleepers will permit the use of longer sleepers, without losing the available bearing now lost in consequence of the springing of sleepers only 5 in. thick. Sleepers 9 ft. long, 10 in. wide, and 3 ft. apart centres, give 13,200 square feet of bearing upon the ballast in a mile of single way. Sleepers 10 ft. long, 12 in. wide, and 2 ft. 3 in. apart centres, would give 23,466 square feet, or nearly twice as much. This width and closeness of sleepers would not prevent the proper packing of the ballast, and it would permit of the use of engines of from 50 tons to 75 tons weight—engines which must yet become general, not so much because of the probable increase of traffic as from the greater economy of heavy engines where the permanent way is such as to bear their weight. On land and in steamships there is no limit to the size of engines, merely because the foundations are good; and were the foundations of the permanent way what they ought to be, and were its own structure correspondingly strong, there is no reason why 100 ton locomotives should not become as common as were 10 ton engines in the days of George Stephenson's earlier practice.

But without steel rails there could have been no great improvement in the construction of permanent way. Had they been the

subject of a patent, not of a "non-professional," or, in other words, of a non-railway, man, but owned by a permanent way company of the character of that of fifteen years ago—"good lord!" as Captain Cuttle observed of Sol Gill's suppositious clock, "how that rail would go!" As it is, railway companies have bought (or made), and laid down a few hundred tons of it, almost upon compulsion, or, in other words, because they could not well do without it, grumbling, meanwhile, through their officers, that a rail from five to ten times as good as iron could not be supplied at the same money. There are many high minded railway engineers upon whom we would on no account cast the least word of aspersion, but there are other engineers, too well known, who will "take up" nothing out of which they can make nothing—gentlemen whose sole motto would appear to be *ex nihilo nihil fit*, unless it be in plain English, "palm oil." But like the steam engine, the spinning mill, the hot blast, the locomotive engine, ocean steam navigation, the electric telegraph, and submarine telegraphs, the steel rail had its seven years of probation, and it came out of them well. It has proved itself to be incomparably safer than iron; from five to twenty-five times as durable; to make a better and smoother way, offering less resistance to traction, and to permit of the use of still heavier engines, the very heaviest locomotives which the permanent way will bear without undue injury or wear, being always the most economical. The steel rail has done, to a considerable extent, for the permanent way what the steel tyre has done for the rolling stock, and on all very hard worked lines, such as the railways in and surrounding London, both are indispensable. The Metropolitan and North London railways could now hardly be worked at all with iron rails and tyres, of however good quality. "Converted" iron rails, or rails case-hardened at the top by Dodd's process, steel-headed rails and "puddled steel" rails, the latter a variable and irregular compound of cast and wrought iron, have been put to the test and failed, until now steel and steel only is tolerated. And yet we have engineers at work, figuring equations in compound interest upon the cost of iron and steel rails respectively, as if the latter had nothing but their greater durability to recommend them, engineers to whom all rails would appear to be equally safe, all rails, of whatever material, equally smooth and stiff in respect of the resistances to traction, and engineers, who recommend waiting for another year, until the steel rail patent has expired, well knowing

that with the growing improvement in trade, the increasing competition for hematic iron, Durham coke and spiegelesein—these being the elements of the steel rail manufacture—and that with the heavy demand which must soon arise for steel rails, wherever railroads are, their price is certain to increase by more than any possible diminution due to the removal of the royalty. In France and America all the great lines are being rapidly laid in steel, not only on the score of economy, but as a safeguard against the accidents which were constantly happening, and which occasionally happen here from the breaking of iron rails.

Railway engineers and railway companies must and will learn that upon the perfection of the way depends the highest working economy. After expending millions in Parliamentary struggles, millions for compensation, millions upon earthworks, colossal bridges and viaducts, tunnels by the mile, stations of the grandest dimensions and of superb architecture, and millions for costly locomotive and carriage stock, the question of a few thousand pounds more or less per mile for first-class permanent way is not one upon which true economy in working and in maintenance can be sacrificed. There are railways enough which have cost their £100,000 or more per mile, and plenty that have cost £50,000, whereas the difference between the cost of a really good as compared with an ordinary permanent way—the platform upon which all the functions of a railway are really discharged—need not exceed £3000 per mile.

BELTING FACTS AND FIGURES NO. II.

By J. H. Cooper.

(Continued from page 244)

Tensile Strength of Belts.

"From various experiments, the absolute strength of ordinary belting leather is found to be 3860 pounds to the square inch of cross-section."—*Sci. Amer.*, February, 1860. 84.

R. G. Carlyle, in *Sci. Amer.*, July 1866, p. 35, gives the following results of actual experiments made by him: "Mean breaking tensile strain of five experiments with leather belts, $\frac{3}{16}$-inch thick, and 1 inch wide, 552 pounds. Reduced to $\frac{3}{4}$-inch wide at place of rupture."

Mean of five experiments with leather belts $\frac{3}{16}$-inch thick and 2 inches wide, 1077 pounds. Reduced to $1\frac{5}{8}$ inch wide at place of rupture. Fracture commencing at the edges.

Mean of three experiments with leather belts $\frac{3}{16}$ inch × 3 inch, 1522 pounds. Reduced to $2\frac{3}{8}$ inches wide at place of rupture.

Mean of all per square inch of section, 2846·4 pounds.

"Mean breaking strain, five experiments, of 'three-ply' cotton-filled rubber-belts, 2 inches wide, 1211 pounds. Did not contract perceptibly, and broke all at once, emitting a perceptible smell of rubber."

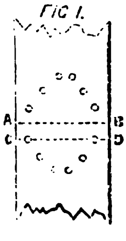
Mean of five experiments with 3-inch rubber belting, 1763 pounds.

"Experiments in great number were made with lacing, of various widths and thicknesses, but the result varied so much—no two being at all alike—and very much appeared to depend on the part of the skin from which the thong was cut. For instance, in some cases, a thong from near the back bone had four times the strength of that from other parts, so I could get no data that was worth noting."

"The next experiments were made to determine the weakening effect of punching belts for the lacing, and the results proved that the belt was weakened to the extent of the sum of the diameters of the holes, if they were in a straight line across the belt."

"The diagram here given will show the position of the holes in the belt which gave the very best results, as its cross-section is only weakened by two holes in any place. A B was not cut, and C D was the invariable line of fracture, which first began at the edges, found assistance at the nearest holes to the edges, and continued across on the same line."

FIG. I.



"From these trials, it can be seen that oval punches would be much superior to any other, as they would cut away less of the cross-section of the belt, and still give ample space for the lacing."

"The next experiments were made with belts punched as in the above diagram, but cut through the line A B, and then laced in a secure manner, results as follows: "In leather belts, tearing began at the holes at $\frac{5}{8}$ths of the breaking strain, and continued on until the lacing tore out at the end holes, when the rest went suddenly."

"In leather belts, after being subjected to one-half of the breaking strain for twenty-four hours, a slight addition to the weight caused

them to tear at the holes, which, after commencing, proceeded rapidly, until the end holes tore out, when it went as before. After being subjected to one-half of the breaking strain for forty-five hours, it went as before stated. They stood one-third of the breaking strain for one week, and at the end of that time showed no signs of fracture."

"In rubber-belts, tearing began at one-third of the breaking strain. They stood one-fourth for twenty-four hours, but tore on a slight addition of weight. They stood one-eighth for one week, without showing any signs of fracture. Eyeletting the holes brought the standing point up to that of leather belting, the clinching of the eyelets on the cotton fibre or filling reducing the tendency to tear. I think that large oval eyelets would materially improve the fastening of such belts, particularly if the eyelets had large flanches so as to grasp or confine the material. They also operate well with leather belting, as their action is to distribute the strain all round the circumference of their holes, which is not the case without them, only a portion of the hole then receiving the strain. They likewise take from the belt the rubbing action of the lacing in rendering through the holes, which must have some effect on the portions in contact, as no belt can be laced so that the lacing will not render to some extent, saying nothing about the action of the same in the passage over pulleys, especially those of small diameter, where the action is continuous while in use transmitting power. My experiments with eyelets were not as satisfactory to me as I could have wished, as I was unable to carry them to any great extent; after so favorable results, on account of not being able to get them sufficiently large to take the lacing. I am confident that if I could have got them large enough and of oval shape, that I could have tested the belts up to very near their breaking strain, I think that eyelets made expressly for the purpose would materially increase the duration of belting."

"I lately made a series of experiments to ascertain facts governing the transmission of power by pulleys with belts." The apparatus consisted of pulleys of different sizes fixed in position with axes horizontal.

The pulleys used were of cast iron, having slightly rounded and smoothly turned faces; over the pulleys different belts were laid, and to the pendent ends certain weights were hung.

"The trials were to be certain weights put on the ends of certain

sized belts, when a preponderance would be put on one side until a perceptible motion occurred, when the whole was noted."

"The following table will give the facts as they were taken:—

TABLE "A."

Diameter of Pulley.	Kind of Belt tried.	Thickness of Belt.	Width of Belt.	Weight on Platform, including Platform and parts.	Weight on Hook, including Hook	Tension of Belt.	Amount of Adhesion.	Proportion existing between Tension and Adhesion.	Remarks. * doubtful.
Ins.	Lea.	Ins.	Ins.	lbs.	lbs.	lbs.	lbs.		
12	"	$\frac{3}{16}$	1	150	50	200	100	2 : 1	Same belt in each case, old but good.
24	"	"	1	150	50	200	100	2 : 1	
12	"	"	2	151	50	201	101	2 : 1	Old lathe belt, sticky.
12	"	"	2	300	100	400	200	2 : 1	Old belt in good order.
24	"	"	2	150	50	200	100	2 : 1	" " "
12	"	"	3	150	50	200	100	2 : 1	" " "
24	"	"	3	303	100	406	206	2 : 1	*" " "
12	Rub.	3-Ply	2	190	50	240	140	12 : 7	" " "
24	"	"	2	369	100	469	269	23 : 18	" " "
36	"	"	4	372	100	472	272	59 : 34	" " "

"The deductions to be made from the above results are, that the adhesion of any belt on a pulley is directly as the tension, and not as the surface in contact, for the same results invariably attended the same tension, whether the belt was double the width, or the pulley double the diameter, or both."

Rubber belting adhered better than leather with the same tension; this was particularly the case when belting, which was worn and glazed somewhat on the bearing side by use, was tried.

New belting did not give good results, and a great deal seemed to depend on the condition of the belt tried. This was not so much the case with leather belting, which was more uniform in the results; new belting gave very near the same result as old belting "not gummed up," for the more it was gummed the better was the adhesion. * * * * * * *

"From my experiments I made up certain rules for practice in all cases, as I was able to bring the elements down to a fixed basis. Since doing so, I have never made a single failure, besides being able to increase the durability of the parts liable to wear, by really knowing what they were subjected to, and what could be demanded of them."

"The following are my rules and practice:—

"I always put the side of the belt which transmits the power on the bottom, when the power is given out horizontally; in that position, the slack side is where it should be—on the top; where the tightener—if one is used—should be. If power is transmitted vertically, I always put a swinging tightener on the slack side, which operates by falling towards a horizontal position."

"I submit belts to 50 pounds per inch of width, of tension, which is made up of the power to be transmitted and their own weight. Where the distance between centers of pulleys give sufficient tension, no tighteners are used. Where they are too close together, I use tighteners—no curve on their face—of as large diameter as is convenient. I count on getting 20 pounds of adhesion from 50 pounds of tension in all cases."

"I count the power to be transmitted as so many pounds at the end of a lever, of the length of the radius of the pulley—the velocity being in the calculation by which the number of pounds were got—and divide the number of pounds by 20, the adhesion, for the width of the belt in inches. I then see if the distance between centers will give the necessary tension to make the first calculation good, if not, the remedy is a tightener, if the distance cannot be increased. If the width of belt got by these means is too great, then the diameter of the pulley—or the radius, which is the same—must be increased; by doing so, the number of pounds to be transmitted at the end of the lever is diminished, I again divide by 20; and if the width is again too great, I again increase the lever until I get it down to what I want it; and the whole proceeding is as certain as it is simple."—R. G. C. in *Sci. Amer.*, July, 1866, p. 51.

Tensile strength of	Calves' skin	....	1890	pounds	per	square inch.
" "	Sheep "	(Brazil)	1610	"	"	"
" "	Horse "	(White)	4000	"	"	"
" "	" "	(Russ.)	3200	"	"	"
" "	" "	(Cord.)	1680	"	"	"
" "	Cow "	....	3981	"	"	"

Lond. Mech. Mag. March, 1863.

Material.

"There is nothing like leather for straps."

"In regard to purchasing belting, I believe that the best white oak tanned leather will be found 50 per cent. the cheapest in the end, and my mode of preparing a new belt is to soak it for about ten minutes in water, then let it dry fifteen minutes, then brush it over two or three times with neat's foot oil. When it is well dried, I put on the belt, and oil it once in two months in cold weather, and once a month in warm."—P. in *Sci. Amer.*, March, 1860, p. 150.

Treatment of Leather for Belts.

"I stuff my belts with a composition of two pounds of tallow, one pound of bag-berry tallow, and one pound of beeswax, heated to the boiling point, and applied directly to both sides by a brush, after which the belts are held close to a red-hot plate to soak the beeswax in, which does not enter the pores of the leather from the brush."

"Care must be taken to have the leather perfectly dry to prevent burning. I placed a kettle of the composition over a black smith's fire, and after melting it, I put in a coil of two-inch belting about sixteen feet long, and boiled it forty-five minutes in the greatest degree of heat I could produce by blowing the fire continually, and the belt when taken out was not in the least injured by the heat of the composition. I then tried a piece of belting damped with water, and found it burnt and crisped in less than half a minute."

"The application of neat's foot oil to belts, opens the pores of the leather and destroys the adhesion of its parts, and in a very short time renders it flaccid and rotten, and a belt will not last half so long stuffed with oil as with the composition above named. Belts stuffed with the composition are impervious to water, and will run well for six months."—J. H. B. *Frank. Ins. Jour.*, June 1837, p. 457.

To keep leather belts in good condition, I have never found anything equal to fish oil mixed with the spent grease of journal box-pans."—C. G. in *Sci. Amer.*, April, 1859.

"When a belt gets harsh or dry, neat's foot oil is the best thing to apply to it."—*Sci. Amer.*, January 1868, p. 55.

"Use neat's foot oil once a week, will give regular speed, and last double the time. Experience has established the correctness of placing the smooth side of the belt next the drum or pulley."—H. M. in *Sci. Amer.*, June, 1848, p. 326.

Condition of Belts.

"Soft and pliable belts have three times the adhesiveness of those made from the same leather, but which are hard and stiff."

"It is generally reckoned that from 1 to 2·2 per cent. of the power communicated is lost by the stiffness of a leather belt."

Slipping Tendency.

Three pulleys were fixed on an immovable shaft; one was a smooth iron pulley, like those in common use, one was covered with leather, and one with gum. A 3-inch leather belt about 7 feet long, was thrown over the iron pulley with thirty-two pounds on each end to give adhesion. It was found by experiment that forty-eight pounds additional on one side were required to produce slippage. Sixty-four pounds additional when on the leather-covered pulley, and 128 pounds additional when on the gum-covered pulley.

A 3-inch vulcanized belt under similar treatment, gave the following result: 90 pounds on the iron pulley, 128 on the leather, and 183 on the rubber.

For record of experiments, see *Sci. Amer.*, March, 1859, 216.

This record is unfortunate, in not giving the diameter of pulleys, nor the condition of the several belts used. The leather belt is spoken of as being of "good quality," but there is a vast difference between simply the quality of the leather and the condition of a belt with reference to its tendency to slip.

It is not adhesion alone we want to prove the better belt; beyond a certain amount it is rather an injury to the belt than an advantage in its use; for slippage is to be preferred to abrasion, when rapid destruction of the belt would result from the closeness of its striking; an infirmity to which rubber belts are liable.

(To be continued.)

Mechanics, Physics, and Chemistry.

THE SUGAR INSECT—ACARUS SACCHARI—FOUND IN RAW SUGAR.

By Robert Niccol, Esq.*

Raw sugar should never be used for dietetic or domestic purposes; because it contains organic impurities; and more especially immense numbers of disgusting-looking insects, termed the "Sugar Insect"—found to be invariably present in *raw* or *unrefined* sugar. This insect is known by scientific men as the *Acarus Sacchari;* and when seen by the aid of a microscope, is found very much to resemble the sea-crab in its appearance.—See the accompanying engraving, which represents the insect as magnified to about 200 diameters.

No one, indeed, who has seen the filth and gross impurities extracted from the raw sugar in a refinery, could ever after use anything but the refined article. Pure sugar is, indeed, almost as desirable an article of food as pure water; and all should be anxious to substitute the *refined* for the *raw* material. Bad water and raw sugar abound in animalcules and vegetable impurities; but pure water and refined sugar are free from such. There are many grocers who sell raw sugar under the notion that it is more economical to their customers than the refined article; and the latter parties (unaware of anything to the contrary) readily purchase the commodity under this impression. This is, however, a great mistake, which requires to be at once corrected. The finest qualities of *raw* sugar do invariably contain very gross impurities; but the cheapest kind of *refined* sugar is perfectly pure and wholesome in every respect; and it can be obtained at the grocer's shop at as reasonable a price as the raw material—the refined article being invariably found to be genuine, in so far at least as its purity and wholesome qualities are concerned. This, let it be observed, is no mere haphazard assertion; for it is founded on fact: and the writer submits the following in proof of what he now states.

The following are extracts from a pamphlet on the subject by Professor Cameron, of Dublin:—

* From an Essay on Sugar and Sugar Refining. Edinburgh: Published by Williams & Norgate.

"In my capacity of public analyst for the city of Dublin, I have had occasion to examine, more or less minutely, nearly one hundred and fifty specimens of sugar, in quality varying from the purest white to the darkest brown. The greater number of these samples were perfectly genuine: some were of rather indifferent quality: and the rest—about fifteen—were so impure as to be quite unfit for use: they abounded in organic filth, and contained great numbers of disgusting insects. All the samples of very inferior sugar were of the kind known as raw; and in no instance did I detect in the refined article the slightest trace of any substance injurious to the health or repugnant to the feelings. With such facts as these before me, and writing in the interest of the consumer, I advocate the exclusive use of refined sugar. I unhesitatingly assert that no one who pays any attention to the purity of his food, aware of the nature of the impurities so frequently abounding in the raw article, could, without a feeling of loathing, make use of it. If, then, the exclusive use of sugar be a desideratum, it is not less desirable that those who are engaged in the manufacture of that article should receive due encouragement, consistent, of course, with the principles of free trade, from the governing bodies. But it will hardly be credited by those not well informed on the subject of our national finances, that the present method of levying the duty upon sugar is *needlessly* inimical to the British refiner. It is so arranged that it obliges the planter to attempt, under the most adverse conditions, the refinement of sugar: it compels the British refiner to purchase the semipurified article, and to undo all that the colonial refiner had done; and, finally, it makes the low class sugar consumed by the poorer classes pay more duty, in proportion to the pure sugar present, than the superior article which is purchased by the middle and upper classes. The use of raw sugar is rapidly on the decline, and I venture to hope that the publication of this little treatise will aid to utterly extinguish it. Should its pages be glanced over by any influential member of the Legislature, I trust it may be the means of inducing him to turn his attention to the present anomalous method of levying the sugar duty, with a view to its early reformation.

"The insects found in sugar are Beetles and *Acari*, or mites. The beetles, which are more familiarly known to the sugar dealers than to the general public, may frequently be seen running nimbly along the tables in the sugar warerooms. The *Acari* are minute insects, and do not attract attention. There are several kinds of *Acari*: the

SUGAR INSECT.

"Acarus Sacchari."

FOUND IN RAW SUGAR.

Fig. 1.

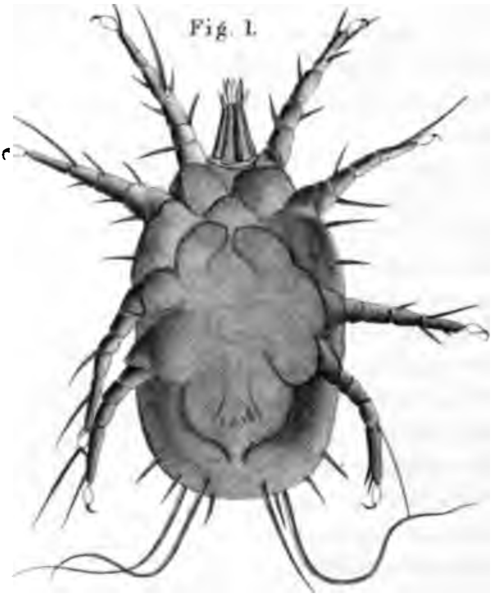


Fig. 2.

DRAWN FROM LIFE FROM INSECTS FOUND IN GROCERY MAURITIUS SUGAR.

By Smith, Beck & Beck, Microscopists, London.

Bowen & Co lith Phila.

cheese mite, the insect found in partially decomposed flour, and the minute parasite, which, by burrowing beneath the skin, produces the disease termed the itch—are all different varieties of *Acari.* The mite found in raw sugar is termed the *Acarus sacchari*, or Sugar Insect: its shape is very accurately shown in the accompanying engravings—Fig. 1 representing the under side, and Fig. 2 the upper side of the insect.*

"The *Acarus sacchari* is a formidably organized, exceedingly lively, and decidedly ugly, little animal. From its oval-shaped body, stretches forth a proboscis terminating in a kind of scissors, with which it seizes upon its food. Its organs of locomotion consist of eight legs, each jointed and furnished at its extremity with a hook. In the sugar its movements from one place to another are necessarily very slow, but when placed on a perfectly clean and dry surface it moves along with great rapidity. It has been stated that the *Acarus scabiei*, or itch insect, possesses the power of leaping, but all my attempts to induce the *Acarus sacchari* to make a jump failed, although it was placed in the most favorable positions for the performance of such a feat.

"The disease termed *psora*, or *scabies* by medical men, but more popularly known by the expressive designation of the 'itch,' is, I venture to hope, only known by name to my readers. It is, I admit, not a nice theme to discourse upon, more especially in connection with such a subject as sugar; but as this malady and its cause are intimately connected with my objection to the use of raw sugar as food, I cannot avoid—even at the risk of offending the sensibilities of some of my readers—alluding to them. So early as the twelfth century, an Arabian physician, named Abinzoar, observed that a skin disease was produced by the ravages of little insects. They burrowed, he says, beneath the skin of the hands, legs and feet, and produced pustles, containing fluid. From the description of these insects given by Abinzoar, it is quite evident that they were not 'little lice,' as he terms them, but a species of mite, or *Acarus.* The same kind of insect was noticed some centuries afterwards by many distinguished physicians and naturalists, one of whom, named Bonomo, described it by the aid of a drawing, in the year 1683. The itch, then, is proved to be produced by this *Acarus* making

* For this engraving of the sugar insect the author is much indebted to Alfred Fryer, Esq., of the well-known firm of Fryer, Benson & Forster, sugar refiners, Manchester.

burrows beneath the skin, and depositing therein its eggs; and hence the insect has been named the *Acarus scabiei*, or scab mite. Mange in horses, cattle and dogs, and scab in sheep, are essentially the same disease as itch in man. As a general rule the persons most liable to be preyed upon by the *Acarus scabiei* belong to the lower classes—in fact, are members of the 'great unwashed' family: the disease is very rare amongst the middle and upper ranks, and, indeed, wherever the abundant use of soap and of clean linen prevails. Now, it is a note-worthy fact, that grocers' assistants and sugar warehouse-men are peculiarly liable to a kind of itch which affects their hands and wrists, but does not extend to any other part. These persons are usually of cleanly habits, and do not belong to the classes amongst whom the ordinary itch is so prevalent; there is, therefore, but one way of accounting for their tendency to contract that disease—namely, that the *Acarus sacchari*, having, like its congener, the *Acarus scabiei*, burrowing propensities, bores into their skin, and breeds there. The two kinds of *Acari* resemble each other very closely,* but the sugar insect appears to be the larger and more formidable. So common is this pustulous disease amongst persons engaged in the 'handling' (*i. e.* mixing) of sugar, that it has been termed the 'grocer's itch;' but I doubt very much that it differs in any specific respect from the ordinary variety of that nasty complaint. My colleague, Dr. Symes, surgeon to Dr. Steevens' Hospital, assures me that persons suffering from 'grocer's itch' are always to be found amongst the extern patients treated at that institution.

The number of *Acari* found in raw sugar is sometimes exceedingly great, and in no instance is the article quite free from either the insects or their ova (eggs). Dr. Hassall (who was the first to notice their general occurrence in the raw sugar sold in London,) found them in a living state in no fewer than 69 out of 72 samples. He did not detect them in a single specimen of refined sugar. The results of my examination of the sugar sold in Dublin coincided pretty closely with Dr. Hassall's experience. In the refined sorts, I found nothing but crystalizable and non-crystalizable sugar, and a little saline matter; in the raw kinds, organic and mineral filth—often in great abundance. One of the samples which I examined, contained a larger number of insects than I believe had previously been noticed, or at least recorded, by any other observer. It was

* By some authorities they are considered to be identical.

sent to me, together with other articles, in May last (1863), by Mr. Horner, the master of the South Dublin Union Workhouse, and the following is the report which I made upon it: I have rarely examined a more inferior sample of sugar; it is extremely damp, contains a very large proportion of treacle, and a considerable amount of such impurities as sporules of a fungus, particles of cane, albumen, and starch granules. These substances, however, though greatly detracting from the value of the sugar, are not injurious to health. I cannot say as much for another impurity which exists in great abundance in this sample—namely, a species of *Acarus*, closely resembling in appearance and nature the insect which, by burrowing into the skin, produces the itch. It is no exaggeration to affirm that there cannot be less than 100,000 of these insects in every pound of this sugar. In ten grains weight, I estimated no fewer than 500, most of which were so large as to be distinctly visible to the naked eye. It is inconceivable that thousands of these creatures can be introduced into the stomach of a human being without serious endangerment to health. But not only is such sugar as this sample detrimental to health, it is also the least economical kind which can be employed. It greatly impairs the flavor of tea and coffee; and its high proportion of water and other useless ingredients lowers its sweetening power to an extent which even its low price fails to compensate for. Many persons believe that coarse brown sugar sweetens better, or, to use the common phrase, 'goes farther' than white sugar; but that is a mistake. A tea-spoonful of damp brown sugar will certainly sweeten a larger quantity of fluid than a spoonful of white sugar; but it does so because it is much heavier than the latter; but if equal weights be used it will be found that the white variety is by far the better sweetener. *The kind of sugar which is both healthful and economical is the dry, large grained, and light colored variety.* If you cannot obtain such an article, you should purchase the lightest brown kind; and bear in mind that such sugar as I have examined for you is the most inimical to health, and the least value for your money which you could possibly get.

"The publication of the foregoing report in the newspapers excited considerable interest in the public mind; for, excepting a few scientific men, no one in Dublin appeared to have been previously aware of the existence of the *Acarus sacchari.* The assertion that one pound weight of raw sugar contained a hundred

thousand active insects, must, no doubt, have appeared incredible to some people; but that I was not guilty of exaggerating the number was proved by the results of subsequent examinations made by other observers. A committee of microscopists, composed of Drs. Aldridge, Minchin, Symes and Booth, and Mr. Reynolds, visited the workhouse, and, in the presence of its officials, examined the sugar and satisfied themselves that my account of it was, in every respect, an accurate one. Two samples of the sugar were also examined, one by Dr. John Barker, Curator of the Royal College of Surgeons, Ireland, the other by Dr. Hassall, of London, a very eminent authority upon the subject. In fifteen grains weight, Dr. Hassall found considerably over 100 living insects, or at the rate of 42,000 per pound; and Dr. Barker estimated no fewer than 1,400 in forty-five grains weight, or at the rate of 268,000 *Acari* in each pound weight of sugar.

"With the exception of the date sugar made in the East,* every kind of raw sugar contains *Acari*. They are least numerous in the very damp, treacley kinds, because, as they are air-breathing animals, they cannot exist in treacle or water. If a spoonful of raw sugar be dissolved in a wine-glass full of water, the animalcules will speedily come to the surface, from which they may be skimmed off and transferred to the object-glass of the microscope. On the surface of the water they appear as white specks, and as they swim about vigorously, their movements are quite apparent to the naked eye.

"The *Acari sacchari* do not occur in refined sugar of any quality for the following reasons:—Firstly, because they cannot pass through the charcoal filters of the refinery; secondly, because refined sugar does not contain any nitrogenous substance (such as albumen) upon which they could feed—and I have already shown that even the most insignificant animals cannot subsist solely upon sugar, or upon any other kind of food destitute of nitrogen. The only impurity found, and that rarely, in refined sugar, is a trace of iron; its origin is easily explained: At the refinery, the sugar, after its solution in water has been effected, is sometimes put into iron cisterns, where it remains until filters are ready for its reception. If, through negligence, the solution is allowed to remain too long in contact with the iron, it is certain to dissolve a minute portion of the metal, from which its subsequent treatment fails to

* The date sugar, which is free from *Acari*, is practically a refined kind; its crystals having been repeatedly "clayed," or washed with water.

entirely separate it. When iron in solution is brought into contact with the body termed *tannic acid*, the two combine and form a black substance, which is the basis of most kinds of black ink. Tannic acid is a natural ingredient of tea; if, therefore, sugar containing iron be dissolved in an infusion of tea, the fluid will instantly acquire an inky hue. The presence of a small quantity of iron in sugar does not in the slightest degree injure its nutritive or healthful qualities; still as tea resembling ink in *appearance*, however agreeable to the palate, would be displeasing to the eye, sugar which would thus affect its color is unfitted for domestic use.

"Would any one, with the slightest pretension to cleanly notions, drink stagnant water if he could as easily obtain the element pure and sparkling from the fountain? May I not add, is there any one so indifferent as to the purity of his food, who would consume raw sugar, *knowing* it to be teeming with disgusting forms of animal life, if the pure article were as readily obtainable? The sanitary reformers have clearly proved that the health of a community is, to a great extent, dependent upon the quality of the water they drink; and the public at large accept the results of the philosopher's reasoning. At the present moment the citizens of Dublin are heavily increasing their already ponderous load of taxation for the purpose of obtaining an abundant supply of pure water. The water which the citizens of Dublin at present use is considered unwholesome, because it contains low forms of vegetable life, and abounds in animalcules; and these are just the kinds of impurities which exist—but in immensely greater quantities—in raw sugar. Is it not, therefore, but rational that if we substititute the pellucid water of the Vartry for the stagnant fluid of the canals, we should for the same reason reject the filthy raw sugar, and supply its place with the purified products of the refiner? The parallelism, in a sanitary point of view, between bad water and raw sugar is complete: it is equally so between pure water and refined sugar."

ON THE INFLAMMABILITY OF PETROLEUM AND SCHIST OILS.

By Dr. Robert Peltzer.

(Translated from Dingler's Polytechnic Journal, Vol. 189, page 61, by Dr. Adolph Ott.)

I have lately made experiments on the inflammability of different products of distillation which were derived from Pennsylvania petroleum and bituminous schists from Autun, Dept. Saône and

Loire in France. The same were conducted in the refinery of Messrs. Cogniet, Maréchal & Co., and made by the special request of M. Cogniet. The following are the results of these experiments:

PETROLEUM.		SCHIST OIL.	
Density.	Inflammability. Takes fire at—	Density.	Inflammability. Takes fire at—
0·643	— 5·8° F.	0·769	+ 10·4° F.
0·686	— 5·8	0·791	66·2
0·700	— 2·2	0·805	95·
0·740	+ 59·0	0·814	118·4
0·748	+ 60·8	0·823	140·
0·750	+ 62·6	0·841	176·
0·760	95·	0·851	186·8
0·775	113·	0·880	208·4
0·783	122·	Portion soldifying at 59° F.	206·6
0·792	167·	Crude Schist Oil of 0·882.	82·4
0·805	194·		
0·822	230·		
0·831	203·		
0·848	158·		
0·850	136·		
Crude petroleum of 0·802	59·		
Heavy oils from the distillation of kerosene.	343·4		
Paraffine of melting point 129·2° F.	429·8		

The oils were heated in a small capsule over a water or paraffine bath, a thermometer being inserted in the oil, and a thin burning wick being held over the same.

The petroleum oils which were experimented upon, were very differently obtained, a part of them were gathered directly from the cooling worms in refineries, others were obtained by fractional distillation in small retorts, and still others by evaporation of specifically light mixtures.

The two first samples of the density of 0·643 and 0·686 already took fire at 5·8° F., henceforth the inflammability diminishes till the density of 0·822 is reached. From this point we again see it increase. This remarkable fact is easily explained, when we consider that the high temperature which is necessary to distil the oils of 0·822, is sufficient to produce a partial decomposition of the higher boiling oils in the retort.

This admission is sufficiently confirmed by the experiment. When the distilled oils had reached the density of 0·822, the fan under the retort was drawn out. In producing a light oil of 0·800, distillers generally gather only the portions which come up to this point; the first fractions which are used with the illuminating oil possess a specific weight of 0·750; the mixture does not then take fire below 96·7° F. The remainder in the retort may be heated to 343·4° F. before it is inflamed by a burning wick. When, however, after the distillate had reached the specific gravity of 0·822, the heat was increased, as it is done for the production of lubricating oils; the inflammability was also increased, as is seen from the foregoing table.

Refined paraffine of a melting point of 129·2° F., could be heated to 429·8° F.; it then took fire, but without a prior decomposition being noticed, which obviously had taken place in the distillation of the heavy oils and crude oil containing paraffine masses.

The schist oil samples were obtained from a distillation on a small scale. The same was carried out in a cast iron retort of 2½ gallons capacity on naked fire. The oils were purified and from Autun. It is striking that the latter are a great deal more inflammable than the petroleum oils of the same density. Prof. Maroc, of Stuttgardt, also indicates the inflammability of a schist oil, which he does not designate further than as being at 63·5° F.

It is highly probable that a similar decomposition goes on in the distillation of schist oils at an elevated temperature, only in a less striking manner than is the case with petroleum. Unhappily, my choice was very limited, and I was specially in want of the distillates from the crude heavy oils for the production of lubricators, otherwise the decomposition of the schist oils could have been more precisely determined.

*Upon this decomposition a process could be founded for changing the heavy petroleum oils by a high heat (at least partially) into illuminating oils, as Mr. Breitenlohner, of Chlumetz, Bohemia, has already done with heavy peat oils.**

This principle has already found application in the refinery of Messrs. Cogniet, Maréchal & Co., as yet, however, on a very limited scale.

From the foregoing table we notice a diminution of the inflammability with the increase of density in case no decomposition has

* **Polytechnic Journal of Dingler, CLXVII., page 378.**

yet taken place by too elevated a temperature; but even an approximate relation between these two points is, however, not perceivable. If the greater or less inclination of the oils to inflame, was simply dependent upon the boiling points of the single fractions, which would represent more or less constant mixtures of hydro-carbons of the series $C^{2n} H^{2n} \times 2$, as isolated by Cahours, Pelouze* and Schorlemmer† than a fixed relation between the inflammability and density would be the necessary consequence; this relation is, however, very probably concealed by a different degree of absorption by the various "fractions" of the highly inflammable gases, which are met with in the oils.

A fraction which holds a certain quantity of gas, possesses also a corresponding inclination to inflame.

For making the crude petroleum applicable and perfectly safe for the heating of steam boilers, it would be necessary to separate all the oils until the density of 0·783 is reached, and then to free it from the absorbed gases. Though oils may yet be present, which are inflammable from 1·22 to 1·67° F., their per centage is so small that the fluid will bear a heat of 176 to 212° F. without there being any danger of explosion. The oil below the density of 0·783 could be sold partly as kerosene, partly as essence for the so-called magic lamp.

LECTURE-NOTES ON PHYSICS.

BY PROF. ALFRED M. MAYER, PH.D.

(Continued from page 258).

§ VI. *Capillary Attraction.*

THE phenomena of capillary attraction consist in the elevation or depression of the surfaces of liquids along the line of contact with the walls of the vessels which contain them; in the ascent or depression of liquids between slightly separated plates, or in tubes of such small internal diameters as to approach to the dimensions of a hair; whence the name of capillarity, from *capillus*, a hair.

These effects are due to the attractions of the molecules of the

* Pelouze, Comptes Rendus, Vol. LVI., page 595; Vol. LVII., page 62.

† Schorlemmer, Chemical News, 1863, page 157.

liquid for each other combined with the attractions existing between them and the molecules of the solid.

Generalization of the Phenomena of Capillary Attraction.

1. The ascent or depression of the liquid is inversely as the diameter of the tube; provided that this diameter does not exceed two millimêtres. In tubes over twenty millimêtres in diameter, there is neither elevation or depression of liquids.

2. The phenomena are independent of the pressure to which the apparatus is subjected; being the same in vacuo as in compressed air.

3. They do not depend on the thickness of the tube; hence the action of the tube is limited in its effects to insensible distances.

4. The phenomena vary with the material of the tube, and with the nature of the liquid; thus, in a tube of glass, water rises above and mercury is depressed below the level of the outside liquid. The following table of the experiments of M. Frankenheim, gives the heights in millimêtres to which different liquids rise, at a temperature of 0° C., in a glass tube of 1 millimêtre in diameter.

LIQUIDS.	DENSITY.	ELEVATION.
Water....................	1·000	30·73
Formic Acid	1·105	20·40
Acetic Acid.............	1·290	17·02
Sulphuric Acid..........	1·840	16·80
Solution of Potassa...	1·274	15·40
Petroleum	0·847	13·90
Spirits of Turpentine..	0 890	13·52
Acetic Ether............	0·905	12·20
Alcohol	0·821	12·10
Alcohol..................	0·967	14·54
Ether....................	0 737	10·80
Bisulphide of Carbon..	1·290	10·20

5. When the liquid *wets* the tube, it rises above the level of the

liquid outside the tube; and in this case the surface of the elevated liquid is *concave.*

Example. Water in glass tube.

6. When the liquid *does not wet* the tube, it is depressed below the surface of the exterior liquid; and in this case, the surface of the liquid in the tube is convex.

Example. Mercury in tube of glass.

7. When the liquid in the tube has a plane surface, there is neither elevation or depression.

Example. Water in a tube of steel.

These facts are readily explained by the atomic theory, of which they are a beautiful illustration and a natural deduction.

(*a.*) An attraction exists between the neighboring molecules of a liquid, and between the molecules of a liquid and of the contiguous solid.

(*b.*) This force decreases very rapidly as the distance between the molecules increases, and becomes null when that distance exceeds *the radius of sensible attraction.*

(*c.*) The attraction existing between the molecules forming the surface of a liquid, and those extending below the surface as far as the radius of sensible attraction, produces a *molecular pressure*, or tension, on this surface, whose effect has to be added to the pressures produced by gravity and the atmosphere.

(*d.*) The molecular pressure is greater with a convex and less with a concave than with a plane liquid surface.

The truth of the four preceding postulates, is made clear by what follows:

Let S S′, Fig. 3, be a liquid surface of any form. M is a molecule on the surface; M′ is a molecule distant from the surface less than the radius of sensible attraction; and M″ a molecule whose distance from the surface equals the radius of sensible attraction; while all molecules between S S′ and R R′ are distant from the surface less than the radius of sensible attraction.

The molecule, M, on the surface, is attracted downward by all the molecules contained in the portion of sphere which has for its radius M P, the radius of sensible attraction. The effect of all these attractions on M will be a resultant in the direction M P, perpendicular to the surface.

The molecule, M′, is attracted by all the molecules contained in the spherical portion A B C, which we can divide into three parts by

three equidistant planes, A B, P Q, A′ B′, parallel to the surface, S S′. The attraction produced by A B P Q, is destroyed by the attraction of P Q A′ B′, and therefore the molecule M′ is drawn downward as though it were attracted only by the liquid contained in A′ B′ C, which gives a resultant, P′, also perpendicular to the surface, but less than P.

The molecule, M″, whose distance from the surface equals the radius of sensible attraction, and all other molecules placed at greater distances, are equally attracted on all sides, and therefore they produce no tension in the surface-film of the liquid, which has for its thickness the radius of sensible attraction.

The influence of the curvature of the liquid surface on the molecular pressure.

Let M′, Fig. 4, be a molecule at a distance M H from the surface S S′ of the liquid. With M as a centre, draw a sphere whose radius M′ P equals the radius of sensible attraction.

If the surface is a plane, A B, the attractions of the liquid in A B P Q are destroyed by those produced by the symmetrical portion below, A′ B′ P Q, and there remains for resultant only the action of A′ B′ C.

Suppose the surface concave and D H E; if we draw through H′ the symmetrical surface, D′ H′ E′, it is evident that the attractions of the molecules comprised between D H E P Q and of those contained within D′ H′ E′ P Q equal and oppose each other, and there remains only the attraction of D′ H′ E′ C on M′, which is less than when the surface was a plane.

If the surface is convex, and is represented by K H L, draw the symmetrical surface, K′ H′ L′; then the efficient attracting portion of the liquid will be increased and represented by K′ G′ L′, and consequently the molecular pressure is greater with a convex than with a plane surface.

We can now explain the rise and depression of liquids in capillary tubes.

When the surface of the liquid in the tube is *concave*, the molecular pressure on the liquid in the tube is less than the pressure on the liquid outside the tube, and therefore the liquid rises in the tube to a height which measures the diminution of pressure produced by the concave surface.

When the surface of the liquid in the tube is *plane*, there is

neither elevation or depression, for the pressures are the same on the surfaces of the liquid inside and outside the tube.

When the surface of the liquid in the tube is convex, the molecular pressure on the liquid in the tube is more than the pressure on the liquid outside the tube, and therefore the liquid column is depressed in the tube below the level of the outside liquid, and the depth to which the column is forced below this level, is the measure of the pressure produced by the convex surface.

As we have seen that the elevation or depression of liquids in capillary tubes, is due to a diminution or increase of molecular pressure, produced by a concave or convex surface, it remains, to render the explanation complete, to show the cause of the special figure of each surface.

Cause of the (1) plane, (2) concave, and (3) convex surfaces of liquids in capillary tubes.

Let D A in Figs. 5, 6 and 7, be the vertical surface of a solid plunged in liquids, whose surfaces are M L. Let M be a molecule of the surface of the liquid contiguous to the plate. This molecule is attracted by all the molecules contained in the quarter-spheres D M C and A M C, whose radii are equal to the distance of sensible attraction; giving as resultants M S and M S′, while the resultant of the attractions of the liquid on the molecule, M, will be M. P.

Three cases can present themselves.

1. If the resultant, M P, Fig. 5, is *twice* M S, or its equal, M S′, the effect of these three attractions on M will be the resultant, M R: which being perpendicular to the liquid surface, the fluid will remain *horizontal*, for the surface of a liquid is always perpendicular to the forces acting on it.

2. If the resultant, M. P, Fig. 6, is *less than twice* M S or M S′, the three attractions will result in M R, which will produce a *concave* surface M L′, inclined against the plate.

3. If the resultant, M P, Fig. 7, is *more than twice* M S or M S′, the resultant of the three attractions on liquid contiguous to solid will be M R, which will, for the reason given above, produce the surface M′ L′, which will be *convex*.

The above results may be expressed concisely as follows:

I. On the free surface of every liquid there exists a molecular pressure from without inward, which always adds its effect to that produced by gravity and the pressure of the air.

II. The intensity of this molecular pressure varies with the form

of the surface, being greater when the surface is convex and less when concave, than when it is plane.

III. The form of a liquid surface in a tube, depends on the relative amounts of attraction existing between the molecules of the liquid and the molecules of the solid and of the liquid.

1. When the attraction between the molecules of the liquid is *twice* as great as the attraction between the molecules of the liquid and those contained in an equal portion of the solid, the surface in the capillary tube is *horizontal.*

2. When the attraction between the molecules of the liquid is *less than twice* that existing between the molecules of the liquid and solid, the surface in the tube is *concave.*

3. When the attraction between the molecules of the liquid *is more than twice* that between the molecules of the liquid and solid, the surface in the tube is *convex.*

IV. When the surface of the liquid in the capillary tube is (*a*) *horizontal*, it is in the same plane with the exterior liquid. (*b*) *concave*, it is above the plane of the exterior liquid. (*c*) *convex*, it is below the plane of the exterior liquid.

V. The amount of elevation or of depression of the same liquid in tubes of the same material, is inversely as the diameter of these tubes. This is known as the law of Jurin, after the philosopher who established it; and with the aid of the table already given, we can by means of it readily calculate the heights to which different liquids will rise in glass tubes of various dimensions, contained within diameters of two millimêtres to a few hundredths of a millimêtre.

The reason of this law is as follows. The force which elevates or depresses the liquid columns in the tubes depends evidently, from what has preceded, upon the number of the molecules on the surface of the liquid contiguous to the sides of the tubes. Therefore, the forces of elevation or of depression are as the interior circumferences of the tubes, and the forces are measured by the quantity (or weight) of liquid elevated above or depressed below the level of the liquid exterior to the capillary tube. Therefore, let h and h' be the lengths of liquid columns elevated or depressed in tubes whose interior diameters are respectively d and d'. Their interior circumferences are πd and $\pi d'$. δ being the specific gravity of the liquid, the weights of the columns elevated or depressed will be $\frac{1}{4}\pi d^2 h \delta$, and $\frac{1}{4}\pi d'^2 h' \delta$. These weights are equal to the forces

which produce the elevations or depressions of the liquid columns, and these forces being to each other as the interior circumferences of the tubes, we have

$$\pi d : \pi d' :: \tfrac{1}{4} \pi d^2 h \delta : \tfrac{1}{4} \pi d'^2 h' \delta$$

or

$$d : d' :: h' : h$$

which is the expression of the law given above.

Experiments.—The apparatus with which Gay Lussac verified the above law, explained and used.

If two squares of plane glass, touching along two vertical edges, are opened to an acute angle and placed in colored water, the liquid will rise between the plates, forming an equilateral hyperbola, and therefore the liquid at various points stands at heights inversely as the distance of the plates at these points.

The relation which exists between the form of the surface which terminates the capillary column and its vertical distance above the plane of the exterior liquid, is beautifully shown by the following experiment, which, with those above cited, can be readily thrown on a screen by means of the lantern and erecting prism of Prof. Morton (see *Journal of Franklin Institute*, Vol. LIII., p. 406). A large glass tube has connected with it a capillary tube, as shown in Fig. 8. Water, colored with carmine, is poured into the larger tube until its level reaches, say, A, and the liquid in the capillary tube just attains the top, S, and in these circumstances, will there form a *concave* surface. Now, on pouring into the large tube more liquid, the concave surface becomes flatter and flatter as the liquid rises in the tube A, until, when the surface rises to B on the same level as S, the terminal surface at S is *a plane*. When liquid is further added until the surface reaches C, at a higher level than S, the capillary surface at S is *convex*.

When S is concave, the molecular pressure on this surface is less than on A by the pressure of the column from the level A to S. When S is plane, equality of pressure exists in both tubes, and therefore the liquid surfaces are in the same plane. When S is convex, more molecular pressure is on S than on C, by the column from S to the level C,

Professor Plateau, of the University of Ghent, has made a series of very important investigations in molecular physics, which are contained in a series of papers entitled, "*Experimental and Theoretical Researches on the Figures of Equilibrium of a Liquid Mass*

withdrawn from the action of Gravity," translated and published by the Smithsonian Institution, in the Reports of 1863, *et seq.* The fifth series of these investigations (Smith. Rep. 1865), contains a research on the molecular pressure exerted by liquid films, with applications to capillary action; and so interesting has this investigation appeared to us, that we thought it proper to present a rather full abstract from Prof. Plateau's paper.

Pressure exerted by a spherical film on the air which it contains. —Application.

"The exterior surface of a laminar sphere being convex in every direction, the pressure which corresponds to it is greater than that of a plane surface, and consequently the resultant of the pressures exerted in any point of the bubble by the two surfaces of the latter, is directed towards the interior; whence it results that the bubble presses on the air which it encloses. It is, indeed, well known that when a soap-bubble has been inflated, and while it is still attached to the tube, if the other extremity of this last be left open, the bubble gradually collapses, expelling the air which it contained through the tube. We see now what is the precise cause of this expulsion.

"But we may go further, and determine according to what law it is, that the pressure, exerted by such a bubble on the confined air, depends on the diameter of that bubble. We can compute, moreover, the exact value of the pressure in question for a bubble having a given diameter, and formed of a given liquid. The pressure corresponding to a point of a laminar figure, has for its expression $A\left(\frac{1}{R}+\frac{1}{R'}\right)$. R and R', standing for the radii of curvature, P being the pressure which a plane surface would occasion, and A a constant which depends on the nature of the liquid. Now, in the case of the spherical figure, we have $R = R' =$ the radius of the sphere. If, therefore, we designate by d the diameter of the bubble, the value of the pressure will simply become $\frac{4A}{d}$, always, be it understood, neglecting the slight thickness of the film; whence it follows that the intensity of the pressure exerted by a laminar spherical bubble on the air which it confines, is in inverse ratio to the diameter of that bubble.

(To be continued.)

RESISTANCE AND TRANSMISSION OF MOTION.

BY PROF. HENRY MORTON, PH. D.

THERE are a number of phenomena more or less directly connected with the effect of high velocity in overcoming resistances, which are commonly regarded as forming a class by themselves, and requiring a special hypothesis for their explanation, or if treated in the established method, calling for an exercise of faith in a train of reasoning not in itself quite unexceptionable, which is at the least a source of discomfort to ordinary minds.

As an illustration of the phenomena to which we allude, we may cite the oft-quoted experiment of shooting a tallow candle through a pine board, the piercing a slate with a pistol ball, without cracking it, &c.

In an able paper by Mr. John C. Trautwine, C. E., entitled "Remarks on Force, Motion, and Inertia," published in this *Journal*, Vol. XLIV., p. 197, some of these difficult questions are very fully expressed. We will quote, for want of space, but one of the illustrations used, although we would strongly recommend the article to all interested, as an accurate and entertaining discussion of a subject which has been inadequately treated by some even of the highest authorities.

After various other and more elaborate illustrations, Mr. Trautwine says: "The ordinary coupling between a locomotive and a heavy train, would break, under the action of an engine capable of imparting to the train at one impulse, a velocity of forty miles an hour; yet it safely transmits the same amount of moving force when imparted by a succession of milder impulses," and further on, "it would seem, that *moving force will of itself* sever mediums through which we may attempt to *transmit* too much of it, to *unresisting matter*, as well as to resisting force."

We believe that the obscurity of this subject will be greatly relieved, if only a little thought is given to the nature of those molecular forces which are the most usual active agents in the resistance and the transmission of motion.

It will then be seen that these are forces which differ in nothing but their range of action, and intensity, from gravity, or other like energies, and may be fairly compared with them in their mode of action.

There is, however, another point, which, though self evident, is apt to be overlooked in our study of all forces, and that is their relation to time, in the respect, that the effect of any force must be proportional to its time of action. Thus, if a force is capable of producing a certain effect in one instant, it will do the same twice over in two instants, and can do but half as much as this in half the time.

We should then first regard the particles of bodies as maintained in their relative positions, not by any general and indefinite condition of contact, but by the constant action of certain forces of great but limited power, and exerting this power, not without reference to time, but on the contrary, with entire dependence upon it; so that each element is exerting so much force in so much time, more in more time, less in less time, in a direct proportion.

These general principles being premised, we will presently assume a case involving the transmission of motion, and test our theory in its explanation.

Our conception of this subject will be rendered more easy, however, if we first consider a parallel case in which gravity might take the place of the transmitting or molecular force.

Imagine the earth at rest in space, with a heavy body in contact with it at some point. If, now, the earth received a motion in a direction radial to the point of contact, and away from it, the heavy body would remain in contact so long as this motion was not greater than that of a body falling from a state of rest, *i.e.* (sixteen feet in the first second, and so on.) In other words, the attractive force between the heavy body and the earth (which here represents the molecular force of our actual experiment), is just equal to that which we express by so much matter (the weight of the heavy body), moved sixteen feet from a state of rest; this power being put forth in the time of one second.

If, now, we required a greater force to be transmitted by this attraction of gravity, either by asking it to move a greater mass at the same rate (as by connecting the heavy body by a string, with another so placed as to be free from all resistances to motion), or by demanding a higher velocity (as by supposing the earth to move more than sixteen feet in the first second), we should simply rupture the connection between the earth and heavy body. By keeping within the limits of the *transmitting* force (which in the above case was gravity, but might be any other), we can transfer part by

part, any amount of force to the second body, which will be converted into motion in it, and be so stored up and accumulated without loss, all resistances being removed.

We will now take up an actual case of transmission to which our principle should supply an explanation.

A weight, W, rests without friction on a level plane, and a power, P (derived say from the action of gravity upon a heavy body), is caused to act upon it by means of a cord passing over a fixed pulley.

In an instant of time, gravity exerts a certain pull upon the heavy body, which we may assume to be transmitted instantly to the first point of the cord; but how is it to travel along the cord? It is clear that the only mechanical connection between the successive points of the cord, is their *cohesive attraction for each other;* it is then by what we may be allowed to call a *stretching* of this attractive force, that the power, P, can be transferred along the cord to W, and by no other means. Now, this molecular force is as we have already seen, properly expressed by, and in fact constituted of, so much power in so much time. If, then, we draw one of these atoms from another with a force which is greater in the *same time* than that uniting them, a rupture will occur, and so much force only be transmitted as was exerted by the molecular power during the time that the weight was acting upon it.

The questions and conditions here noticed, lead us to another cognate subject of similar difficulty, and amenable to similar treatment; we allude to the relations between the moving force and the work done by a moving body.

We say and know that the *vis viva* or work done by a moving body, varies with the square of its velocity, while we know by our previous reasoning, that the force expended in giving it that velocity, only varies with the velocity itself. Thus the force of gravity will give a falling body a double velocity in a double time, during which it must have exerted a double force upon it. Here, then, we have a double force, doing a quadruple work. Is this because by some wonderful and recondite property inherent in "velocity," the double power has been indued with an again doubled efficiency? Many writers leave us to think so; but we, on the contrary, believe that the work done *only seems to increase* more rapidly than the power implied in the increased velocity, by reason of a *loss of efficiency* in the resistances, in the overcoming of which the "work" consists, and in fact, that work in this sense, is no true measure of force.

As we have before seen, the molecular forces (which are those that most commonly play the part of resistances) as well as all others, exert powers proportional to the times of their action. If, then, a moving body with a certain velocity, overcomes a certain number of these resistances, or, for example, penetrates a medium to a certain depth, before its motion is arrested, it has overcome so many resistances, each acting for such a length of time. If, now, the same body with a double velocity, meets the same medium, it will penetrate each resisting element in half the time, and so receive from it but half the resistance it experienced before. If, then, its total force were *only equal* to what it was at first, it would go twice as far, or overcome twice as many resistances; because each of them would be but half as effective as at first. But as we know the double velocity implies a double total force, and thus, considering the doubling of the force and the halving of the resistances, we see why the number of these overcome, or the work done, should be four-fold.

Similar reasoning would apply to the case of a body resisted in its upward motion by the force of gravity. A double velocity would give a four-fold height to its upward path, because, traversing each distance in half the time, gravity would exert but half its former effect within the same space, and so on, as before followed out.

The body would come to rest when exposed *for a double time* to the resisting force of gravity.

It may be objected that the time of action is not the true measure of a force, but rather the distance which it causes a body to move in a given time. But that this is not so, will be seen when we consider that any velocity once implanted in a body, needs no force to maintain it, so that all the motion afterwards executed by reason of that element, is a clear gain having no equivalent of expended force as its representative. Thus, a falling body acquires during the first second, a final velocity of thirty-two feet per second. If gravity then ceased to exist, it would still travel this distance in the next second, while if the force still exist, and is to be expressed by the motion produced, we would have it responsible in the first second for sixteen feet, and in the next for forty-eight.

It is precisely this which introduces the philosophical error into the method of estimating force by the product of mass, into the square of the velocity.

But again, it may be said, the true measure of a force is the heat it develops, and this, as we know, varies with the square of the velocity. We would reply that all development of heat is unquestionably of the nature of overcome resistances. Thus the vibratory motions given to the atoms of bodies, are given in opposition to and by overcoming their molecular forces, and therefore, as in other cases, these forces will each individually oppose a *shorter* resistance to a body with high velocity, and thus render a greater number of their companions necessary to counteract its motion. In other words, the previous explanation may be applied word for word to this case.

Or, we may say, the change produced in the individual atoms of a resisting medium, which we have heretofore called overcoming of their resistances, *is* heat. Therefore, if a double velocity overcomes a four-fold number of resistances, it develops a four-fold amount of heat.

In conclusion, we would again remark that the foregoing discussion is in nowise intended as suggesting a new system of mechanics. The rules at present employed are perfectly correct in their working, and more convenient in form, we think, than any which could be established on another basis. Like many rules and methods in mathematics, they are without reference to the rationale of the process, but accurately fitted to its requirements. Thus, for example, to take a simple case in arithmetic, in place of dividing one fraction by another, we invert the second and multiply. This is perfectly correct and unobjectionable as a method of obtaining certain results, but if the final expression (e.g. $\frac{1}{2} \times \frac{3}{1}$) were regarded as a rational explanation of some process (the inverting step being ignored), it could not well convey a very true or satisfactory impression. So, when we calculate the efficiency of various forces by the formula $f = mv^2$, we are simply transferring one v from the denominator of a fraction expressing the resistance, to the numerator of the quantity expressing the force, which we have a perfect right to do, provided that we recognize this as a *mathematical process*, and not as the expression of a *physical fact*.

Our object in writing the above, is to make clear that this *is* the actual state of the case, and thus, in this and the other points noticed, to offer to those who may feel the appetite for such a supply, the reasoning which has satisfied in ourselves the craving after a rational account of things that had a certain air of paradox about them, as commonly enunciated.

Sunlight & Moonlight

Oct. 3rd 11h 23m.

Oct. 3rd 11h 51m.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

By Prof. Henry Morton, Ph.D.

(Continued from page 277.)

Such, then, are some of the facts which are revealed to us by the light reflected from the moon's surface, and so much do they tell us of her past history and present condition. But such information, and similarly acquired, we also receive from other sources, as in the case of our companion worlds, the planets, whose light, like that of the moon, is but reflected sunlight, modified by, and thus informing us of their special conditions of surface.

As regards the interior planets Mercury and Venus, their propinquity to the sun and their intense illumination, together with other causes, such as their small size, renders our observations most meagre and unsatisfactory, but when we direct our view to Mars, we see much that is of interest, and has a meaning which we may hope to interpret.

We find there a condition of things quite antipodal to that of the lunar surface. The planet Mars is undoubtedly wrapped in an atmosphere loaded with vapor and clouds, and possesses a surface diversified by oceans and continents, lakes and peninsulas. The changes and the observations produced by the movements, formations and dispersions of clouds, makes the determination of the permanent features of this planet very difficult, but yet by a careful comparison of various sets of drawings, such as those of Beer and Madler, made in 1830, those of Father Secchi, made in 1858, and the latest by Mr. J. N. Lockyer, in 1862, we see clearly that certain general markings are permanent after years have elapsed, and regain their original appearance after being temporarily obscured and concealed.

Such, for example, is the part marked *a*, on Plate 5, and known as the Scorpion, and the part marked *b*, which we might well call,

by analogy, the Atlantic, and *c*, the Mediterranean. The formation and grouping of clouds on the other hand, causes certain appearances which we learn to recognize as unconnected with the geographical constitution of the planet, by reason of their evanescent character.

A striking instance is shown in the accompanying plate, which is taken from a series of drawings by Mr. Lockyer, published in the *Memoirs of the Royal Astronomical Society*, 1863, p. 179.

Here we have two views, taken at the interval of half an hour, one bearing date October 3d, 11 h. 23′, the other October 3d, 11 h. 51′.

In the first, it will be observed that the area indicated by *x*, is devoid of all markings except a small rounded shade; in the second, this shade has developed into a chain of three connected lakes. In the first case, we suppose that the region was covered and concealed by a mass of cloud, which subsequently dispersing or perhaps falling as a snow storm, or as a rain shower, left the existing features of the planet evident to our eyes.

The growth and decrease of the snow zones, which surround either pole, and which creep out in the winter of each hemisphere, and melt away again as the time of summer comes to each, is also a curious evidence of a series of meteorological and climatic phenomena, wonderfully in accordance with our own terrestrial experience.

The consideration of these things gives us a vivid impression of the wonderful revealing power of the agent, which we are now studying.

We often admire the wonders of the electric messenger and his timeless flight, annihilating distance, and bringing together the ends of the earth, but what are these achievements compared to those here accomplished.

The electric fluid flashing along the cable-covered wire, can give warning to the coast of England, that a tempest has begun its march across the broad Atlantic, and although now a thousand miles distant, will soon be howling across the chalk cliffs of the island and thundering into its bays, but here the swifter footed light, flashing out from the sun across the fields of space, and turning back to us from its momentary resting place on the continents, or oceans, the mountain summits or their cloudy crowns, the polar snows or equatorial deserts, of this distant planet, tells how a tornado of snow and sleet is at almost the same instant sweeping over that globe *thirty-five millions of miles away.*

The picture which is now thrown upon the screen, shows you at a glance, prepared as you are to interpret the meaning of its various indications by what you have seen before, what we can learn as to the physical constitution of the planet Jupiter. You see a series of belts of an irregular form, but following the line of the planet's equator, and these by their form and by their changes, indicate that when we look towards this planet, we see little more than the cloud masses of its watery atmosphere, drawn out into such zone-like lines, by the action of trade winds.

You now see in turn, the planet Saturn, with his eight satellites and his rings. These last, which have since their discovery been among the mysteries of the universe which seem to defy human ingenuity, are now believed to be, not continuous masses of matter, but troops of satellites, minute, innumerable, closely arrayed, yet moving in independent harmony. A choral band, sweeping in majestic measure round their ruling centre and primary.

Among our reasons for so regarding them, the most prominent are these: When they have been in such position as to be seen edgewise, breaks have been observed in their substance, as is shown, in the figure. Now, a break in a continuous ring, it is easy to prove, must result in its speedy destruction of form and coagulation into a globe, without the possibility of a restoration to the annular shape, but in a swarm of circling planets, such gaps might naturally occur from time to time, and close again without disturbance.

Other changes inconsistent with the continued existence of a continuous mass, are also noticed, such as the longitudinal splitting of the rings, and it is also believed that a scattered interior mass of these minute planets has formed within the inner ring in modern times, being the result of collision and consequent in-falling of the revolving fragments. This cloud, called "the veil," was first seen in 1850 by Bond and Dawes, with difficulty, in their powerful instruments, but is now easily discerned with an objective of but four inches aperture.

(To be continued.)

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 284.)

The surgeons in charge of the splendid hospitals built in and around Philadelphia during our late war, made verbal and written protests against having these hospitals ventilated in winter, because the form adopted by the Government was a little varied (for the purpose of adapting it especially to these temporary buildings) from the time-honored forms to which they had been accustomed from their childhood up. There is one great comfort to you in this characteristic of your regular physicians:—if your doctor was to offer you a medicine you were not accustomed to, do not have the slightest hesitation in taking it, for you may rest perfectly assured that it has been tried in every hospital in the land, and that it is in common use in every other city in the Union before it is offered to you.

It seems to me a little unfortunate that our physicians have fallen into this quiet, easy way of gliding around so elegantly, with their hands in their pockets and their brains in their medicine boxes. Now, this is not because these physicians do not really know better, because, if you were to attend their lectures you would find them discoursing very eloquently on the great importance of the functions of respiration, and the importance of pure air in all cases.

Note.—If you should happen to find the Professor lecturing thus in a close, unventilated room, smelling very badly, this, you must remember, is a strong argument of their appreciation of pure air—as you know doctors never take their own medicine. Or, if you were to go into the office of any one of them, and take up any of the standard text books on their tables, you will find that all eminent medical writers lay very great stress upon the necessity for the most perfect ventilation at all times. They consider it of greater importance than eating, drinking and medicine in the prevention and cure of disease. For instance, here is Carpenter's Human Physiology, which, in summing up a very elaborate article on Respiration, says, page 326:

"Thus it appears that in all climates, and under all conditions of life, the *purity of the atmosphere* habitually respired is essential to the maintenance of that power of resisting disease which, even more

than the ordinary state of health, is a measure of the real vigor of the system. For, owing to the extraordinary capability which the human body possesses of accommodating itself to circumstances, it not unfrequently happens that individuals continue for years to breathe a most unwholesome atmosphere without apparently suffering from it, and thus when they at last succumb to some epidemic disease, their death is attributed solely to the latter, the previous preparation of their bodies for the reception and development of the zymotic poison being altogether overlooked.

"It is impossible, however, for any one who carefully examines the evidence, to hesitate for a moment in the conclusion that the fatality of epidemics is almost invariably in precise proportion to the degree in which an impure atmosphere has been habitually respired, * * * and that by due attention to the various means of promoting atmospheric purity, and especially efficient ventilation and sewerage, the rate of mortality may be enormously decreased, the amount and severity of sickness lowered in at least an equal proportion, and the fatality of epidemics almost completely annihilated. And it cannot be too strongly borne in mind, that the efficacy of such *preventative* measures has been most fully substantiated in regard to many of the very diseases in which the *curative* power of medical treatment has seemed most doubtful, as, for example, in cholera and malignant fevers.

"The practical importance of this subject may be estimated from the startling fact, which inquiries prosecuted under the direction of the Board of Health have recently brought to light, viz: that the *difference* in the annual rates of mortality between the most healthy and the most unhealthy localities in England, amounting to no less than 34 in 1000, is almost entirely due to zymotic diseases, which might be nearly (if not completely) exterminated by well-devised sanitary arrangements. The *lowest* actual mortality is 11 per 1000, while the highest is 45 per 1000, and between these extremes there is every intermediate degree of range. But what may be termed the *inevitable* mortality, arising from diseases which would not be directly affected by sanitary improvements—is a *nearly constant* quantity throughout, namely, the 11 per 1000 of those districts which are free from zymotic diseases.

"The average mortality of all England, in ordinary years, is about 22 per 1000, or just double that to which it might be reduced; so that taking the population of England and Wales (as by the last

census, at nearly 18,000,000, the average annual mortality must be 396,000, of which only 198,000 is *inevitable*, an equal amount being *preventable*."

Thus you see these physicians tell you that one-half of all the sickness and death are "*preventable*." They don't say they can *cure* them with their medicines, but that they are preventable, and that the great means they recommend for accomplishing this wonderful work is pure air—ventilation. But, although they have said this, and re-said it, for the last fifty years, yet it has seemed, as Dr. Hamilton has said, a herculean task to make the public at large comprehend it. So that a whole life spent in teaching the value of pure air has seemed to be a whole life almost wasted.

The extracts that I have just read were written more than ten years ago. But the very careful investigations that have been since conducted by many able and scientific hygienists, only more fully prove these assertions. Perhaps no city presents a stronger contrast between her healthy and unhealthy wards than does the city of New York.

Dr. Harris says of one of the most densely populated wards of New York, the Seventeenth, that the death rate has been for several years less than 17 to the 1000, and even during the terrible heat of July, '66, the uniform low mortality of that ward was scarcely affected. The death rate in this ward, with its 27,000 inhabitants, was, during the six months ending October 1st, (including the cholera summer) only 16½ to the 1000. In the same period the mortality in the notoriously foul Sixth Ward was 54 to the 1000. And although the death rate of Philadelphia is exceedingly favorable, by comparison with some other cities, as, for instance, New York, where it is about 30 to 33, while in Philadelphia it was but 20 deaths to the 1000 of population, yet, you see even that is nearly double what it should be—that it would only be 11 per thousand if we could only avoid those zymotic diseases, or such as are caused exclusively by foul air poisons.

And I believe with an extra ton of coal for each family, and an extra blanket for each bed, so that every chamber might be opened, this night, the one-quarter of one inch, to-morrow night two-quarters, and the next night three-quarters, and so on until every chamber could be kept the whole night in a pure and wholesome condition, and never after closed, we could do much towards saving the 6000 or 7000 lives due to this proper death rate of 11 to the 1000.

But now I have a word to say to you, the people that employ these physicians. They have a good deal of human nature about them after all—they are not so very different from the people amongst whom they live and by whom they are employed. And now, I don't suppose there is a city in the United States in which a physician has to be more exceedingly careful of his *reputation* than in this very city of Philadelphia. And I happen to know something of the reasons for omitting to prescribe, more frequently, fresh air as the medicine most needed for their patients. How many of you, if, being sick, were to have a physician to call frequently, and just say to you. "All you need is more fresh air," would you not say, in your mind (if not out of it), "Well, I think I can attend to getting a little fresh air myself, without paying that doctor two dollars per day for telling me that, and I think, upon the whole, I will get some doctor that will do something for me." So you will probably send for some man you have heard of, as making some wonderful cures of some friends, and if he should happen to be a regular shrewd humbug, he would make a wonderful account of your disease, and finally tell you he thought he had something that would just suit your case, and, as before illustrated, would commence pouring turpentine or kerosene oil on your fires, by which he would create a great smoke and temporary blaze, and this would induce you to exclaim, "What a wonderful man! *he* does something;" and if he could get you out into the fresh air, *that* would soon cure you, perhaps, while you would be giving all the credit to his medicine, and the dollars to him for his trash.

I know some physicians, of most excellent good common sense, who have ideas of their own, and independence enough to express them, and have much more faith in good hygienic rules and regulations, who prescribe pure air, pure water, good wholesome food, and plenty of exercise, but seldom prescribe medicine. These men would have to beg their bread if they had to depend exclusively on popular custom for their living.

And now let us take a new start. Let us put our shoulders to the wheel manfully. We have made a most excellent beginning during the year 1867, and our journalists, too, could they be induced to give a line or two every day for some good hints as to the value of, and the best means of obtaining pure air, such results might be obtained as would astonish the world, and would give one of the grandest examples of hygienic reformation ever recorded.

(To be Continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, September 15th, 1868.

THE meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the Library received since the last meeting of the Institute, from the Royal Astronomical Society, the Royal Geographical Society, the Royal Institution, the Society of Arts, the Chemical Society, the Zoological Society, the Statistical Society, the Institute of Actuaries, London; the Association for the Prevention of Steam Boiler Explosions, Manchester, England; the Geological Survey of India, Calcutta, India; l'academie des Sciences, la Société d'encouragement pour l'industrie Nationale, Paris; la Société Industrielle, Mulhouse, France; der Osterreichen Ingenieur-veriens, der K. K. Geologischen Reichsanstalt, Vienna, Austria Mussée Teyler, Haarlem, Holland; the Smithsonian Institution, Hon. Charles O'Neill, Frederick Emmerick, Washington, D. C.; the Mercantile Library Association, San Francisco, California; the Illinois and St. Louis Bridge Company, St. Douis, Missouri; William F. Roberts, Bethlehem, Pennsylvania; B. H. Bartol, Esq., and Frederick Fraley, Esq., Philadelphia.

The Standing Committees reported their minutes.

The report of the Secretary on Novelties in Science and Art was read. After which the meeting on motion, adjourned.

HENRY MORTON, *Secretary*.

Bibliographical Notices.

On the Construction of Iron Roofs. By Francis Campin.

We have received, from Mr. Van Nostrand, (192 Broadway, New York,) what we believe to be the first example of a book printed throughout by the Photo-Lithographic process, a fact that deserves more than a passing notice. Of course, this process can only be applied in the case of a reprint, and produces, from necessity, a

copy that would satisfy the most exacting Chinaman. None but an expert would dream that this book was printed by other than regularly set-up type. The letters are clear, and stand out beautifully upon the fine toned paper upon which they are printed. The plates appear as fac-simile lithographs, and cannot be made to look better than the original. On the whole, it is a most successful specimen of the new art of Photo-Lithography, and the manner of its "get up" is creditable, in the highest degree, to its enterprising publisher. So much for the appearance and mechanical execution of this book, and we turn now to its contents.

As noticed above, it is a reprint from an English work, that has been most favorably met by the profession. It is divided into three parts: Introductory, Theoretical and Practical.

The first part is a concise statement of the proposed treatment of the subject, under the two topics of "roofs proper" and "domes." In the former class are included those supported by arched structures, lattice girders and trusses. The second comprises the various forms of domes. The author having, in two former volumes, considered the usual arrangements for covering, he restricts himself in the one before us to the analysis of the ribs or girders, with some practical examples.

The second part, upon the "Theory of Roof Construction," is most excellent. Clearly stated, with a simplicity of analysis, by which the tyro in engineering could get a complete insight into the action of forces upon such structures. The subject is entirely divested of the "higher mathematics" some writers seem to consider essential to a proper understanding of mechanical constructions, thus making a "terra incognita" of what ought to be at the finger's end of every engineer. The consideration of the arch form for roofs is incomplete, from the fact that no method of investigating the bending action of a load is given, although this question is not ignored by the author. He considers that it will be amply sufficient merely to calculate the direct thrust at the corner and haunches, methods for doing which he gives on p. 21.

This is all very well for ordinary spans; but it seems to us that in enormous spans like the great roof of the St. Pancras Station, the bending moment is of too serious a nature to be neglected.

The third part is devoted to practical illustrations of the theory developed in the second, merely substituting for trigonometrical expressions their "line values," which simplifies the computations

greatly. We notice one error on p. 31, which could not be avoided, as the process employed for printing must necessarily copy all the errors of the original. The error is not of much consequence, as it is easily discoverable. The notation makes L=ad, when it should be L=ab. The author, in his remarks upon workshop construction, gives thoroughly English views, which are far behind our American practice. Not that Americans have done greater work than the English, but that the American engineer has usually an eye for much simpler details. The author lays much stress upon a proper arrangement for adjusting the parts. This not only necessitates considerable expense in the way of screws and turnbuckles, but also is a dangerous temptation to every mechanic employed in its raising, every one of whom has his idea of "adjustment." In our best American examples, all our roofs are laid out by template, and are either bolted or rivetted, in an unalterable shape, before leaving the shop. When raised, the rafters all pitch in the same plane, to an exactness impossible in trusses adjusted by screws. Then, too, where the English use built sections of "angles," "plates" and "ties," we use solid rolled sections, which simplifies the whole construction. Latterly some of our leading engineers are using wrought iron shoes, instead of cast, a marked improvement on former practice. The plates are full-page lithographs, of a conservatory roof with details, the Broad Street Station of the London and North-western Railway, and the novel roof of the city terminus of the Charing Cross Railway. These three roofs occupy, in all, eight plates.

This is not a voluminous work on roofs, but, as far as it goes, is very complete, and an excellent office companion; and to any engineer who needs a work upon this subject, the contents of which he can apply to his own practice with little labor, we take pleasure in recommending this work of Mr. Campin as, in many respects, the best we have seen.—B.

The Workshop. Edited by Prof. W. Baumer and I. Schnorr and others. No. 8. Published by E. Steiger, 17 N. William Street, New York.

We noticed, some time since, the first numbers of this excellent publication, (which, in its English form, originated with the present year,) and remarked upon the beauty and admirable execution of

the engravings of architectural and other ornaments with which it is filled. (See this *Journal*, Vol. LV., p. 425.) We will at present, therefore, only call the attention of our readers to the fact, that its admirable character is fully maintained, and the present number is, like its predecessors, unrivalled by any publication, both as regards the beauty of its designs or the excellent style of their execution. In addition to its former contents, the work now has, and is to possess in future, if adequately supported, a supplement, containing useful information and advertisements.

The Mechanics' Tool Book, with Practical Rules and Suggestions for use of Machinists, Iron-Workers and others. By W. B. Harrison, Associate Editor of the *American Artisan*. D. Van Nostrand, New York.

This little work will be found of great use by those for whom it is intended, namely, those conducting or employed in small shops, where a few simple tools, such as ordinary lathes and planers, are alone to be found, and must be made to do the work which is to be executed. It does not touch upon the practice of the large shops, where final economy is attained by original large outlay in special machinery for each variety of work, where, to use a familiar expression, somewhat suggestive of the story about "the house that Jack built," a machine is made to make a machine to make a machine.

The author is evidently familiar with the subject he treats, and is evidently relating his own experience, and describing the processes which he has executed with his own hands. Considering its probable readers, one sort of errors with which it abounds are perhaps of little consequence, but it would have done much more credit to its publisher had the number of typographic and grammatical mistakes been reduced to more moderate limits. Thus there are not many pages with less than two, and some, like page 44, with as many as five of such signs of careless proof-reading. E. g. p. 44, "are" for "is" twice, "slope" for "shape" twice, and the word "or" repeated.

A COMPARISON *of some of the Meteorological Phenomena of* SEPTEMBER, 1868, *with those of* SEPTEMBER 1867, *and of the same month for* EIGHTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	September, 1868.	September, 1867.	September, for 18 years.
Thermometer—Highest—degree	88·00°	86·00°	95·00°
" date	12th.	19th.	12th, '56.
Warmest day—mean	82·83	77·83	85·20
" " date	12th.	6th.	6th, '54.
Lowest—degree	48·00	43·00	39·00
" date	17th.	30th.	25th, '56.
Coldest day—mean	54·67	50·00	50·00
" " date	24th.	30th.	30th, '67.
Mean daily oscillation	11·83	14·52	15·72
" " range	5·70	5·36	4·79
Means at 7 A. M.	64·10	63·12	63·81
" 2 P. M.	72·18	73·62	74·48
" 9 P. M.	67·37	66·80	67·08
" for the month	67·88	67·84	68·29
Barometer—Highest—inches	30·441	30·466	30·466
" date	19th.	24th.	24th, '67.
Greatest mean daily pressure	30·367	30·392	30·392
" " " date	19th.	24th.	24th, '67.
Lowest—inches	29·764	29·623	29·281
" date	25th.	29th.	18th, '63.
Least mean daily pressure	29·817	29·726	29·403
" " " date	25th.	29th.	16th, '58.
Mean daily range	0·123	0·136	0·122
Means at 7 A. M.	30·046	30·084	29·963
" 2 P. M.	29·997	30·050	29·920
" 9 P. M.	30·021	30·058	29·944
" for the month	30·022	30·064	29·942
Force of Vapor—Greatest—inches	0·846	0·812	0·991
" date	11th.	17th.	6th, '54.
Least—inches	·172	·125	·125
" date	17th.	30th.	30th, '67.
Means at 7 A. M.	·473	·485	·480
" 2 P. M.	·503	·581	·508
" 9 P. M.	·505	·528	·519
" for the month	·494	·514	·501
Relative Humidity—Greatest—per cent	97·0	95·0	100·0
" date	23d.	3d & 5th.	2d, '54.
Least—per cent	34·0	28·0	28·0
" date	18th.	30th.	30th, '67.
Means at 7 A. M.	74·8	80·2	78·2
" 2 P. M.	60·5	61·4	57·2
" 9 P. M.	72·8	76·9	74·5
" for the month	69·4	72·8	70·0
Clouds—Number of clear days*	7·	11·	10·5
" cloudy days	23·	19·	19·5
Means of sky covered at 7 A. M	73·0	66·8 per ct	59·4
" " " 2 P. M	68·7	49·3	53·1
" " " 9 P. M	59·0	41·7	38·4
" " for the month	66·9	52·5	50·3
Rain—Amount—inches	8·61	1·850	4·529
No. of days on which rain fell	14·	7·	8·6
Prevailing Winds—Times in 1000	s 54°3′w. 082	n69°46′w.125	n89°30′w.169

* Sky one-third or less covered at the hours of observation.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] DECEMBER, 1868. [NO. 6

EDITORIAL.

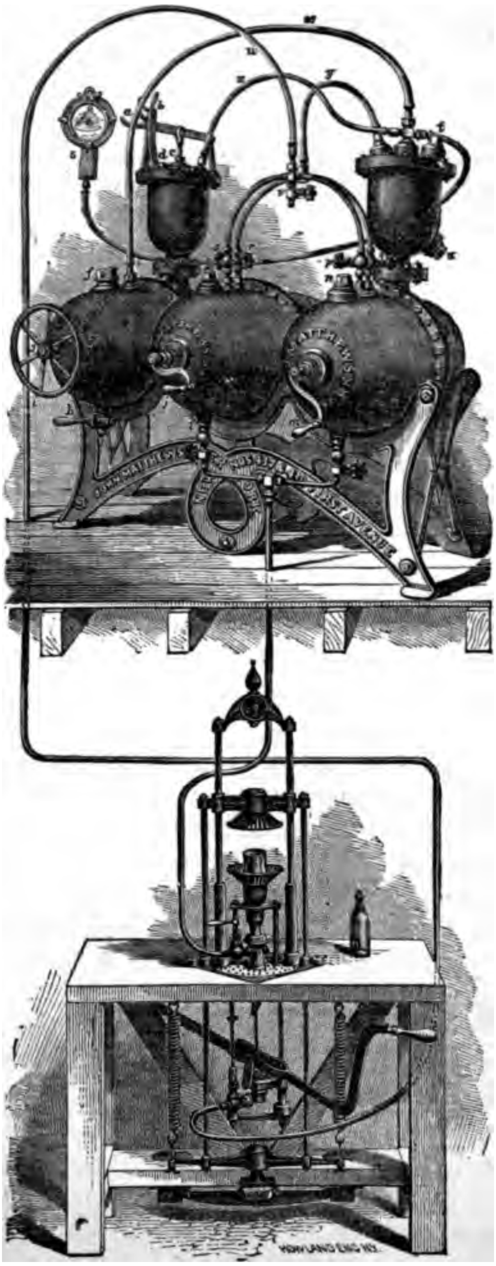
ITEMS AND NOVELTIES.

Soda Water Apparatus—continued.—In our issue of October, we described several of the excellent machines in connection with the above subject, which had been devised and were now employed by Mr. John Matthews, of New York, and we then promised further particulars for our next number. A portion of the present notice, was, in fact, in type, but was crowded out by other matter which came in late, and yet with an imperative demand for admission.

Among the most important of the new arrangements devised and introduced by Mr. Matthews, is that for bottling aerated liquids under pressure; this apparatus, with the aid of the accompanying illustration, we will now explain.

In the usual method of bottling, the pressure of gas on the aerated liquid in the fountain, drives the water through a tube into the bottle. As the liquid enters the bottle, at first, under no pressure,

a large part of its previously-absorbed gas escapes, together with the air in the bottle from the weighted valve on the bottling machine. The escaping gas causes foaming of the liquid, which, becoming entangled with this escaping gas, causes large leaks, especially if wines or liquids containing sugar or extractive matter are bottled. Owing to the disturbance caused by the agitation and escape of gas, the liquid, when closed in the bottle, will frequently reabsorb a portion of the gas in the space above the liquid, causing considerable reduction of pressure. To compensate for this reduction, as well as for the excess of pressure necessary to open the escape-valve, so that the bottle may fill rapidly, the employment of a much higher pressure is required in the fountain than in the bottle.



The system here shown is designed to obviate these objections; and reports from the bottling establish-

ments having it in practical use, are conclusive as to its success. In this system there is no escape-valve at the bottling machine, and the aerated liquid is kept under constant pressure during the entire operation of bottling. All the bottles filled by this system are of equal pressure, and the same pressure as the liquid in the fountain. The fountain, or reservoir is elevated above the bottling machine, and tubes communicating with the aerated liquid, and also with the compressed gas in the fountain, descend to the bottling machine. The bottle, being brought to the filling machine, is first charged with gas from the upper or gas tube, and then communication is made with the lower part of the fountain, the liquid descends to the bottle, and there displaces the gas, which is thus returned to the fountain.

The opening of the gas-valve is automatic: by simply raising the hand-lever, which elevates the gas-tube in the bottle, the communication is opened with the compressed gas in the fountain. If the bottle is filled in an inverted position (as when gravitating stoppers are used), the gas-tube is raised in the bottle to the height to which it is desired to fill the bottle. This ensures filling the bottles all to the same height, and prevents over-filling and consequent breakage. Still liquids, or liquids not yet having generated carbonic acid gas by fermentation, can be readily filled into bottles by this system without exposing them to the action of atmospheric air.

If it is desired to bottle them in bottles requiring an external pressure to sustain, or to close the stopper, the barrel or other reservoir containing the liquid may be separated from the gas reservoir, and, after drawing off the liquid into the bottle, a small quantity of compressed gas may be admitted by depressing the hand-lever and opening the appropriate valve. This system, for liquids under pressure, and for still liquids, is now in successful practical use in a large number of establishments in the United States, and in several in foreign countries. The saving of materials used to generate the gas is estimated to be fully 30 per cent., as compared with the usual method, and as the beverage does not lose its absorbed gas by expansion to a lower pressure than that in the fountain, the low pressure employed in this system produces equally good results, besides avoiding much of the breakage and other losses inseparable from the usual method.

Another of the ingenious contrivances in use by Matthews, is the

arrangement shown in the accompanying cut, which may be described as follows:

A large ovoid glass vessel, having a capacity of 5 to 10 gallons, is provided with a strong iron casing, capable of safely supporting any pressure to which the apparatus would ever be subjected. In this casing the glass vessel is supported by large blocks of sheet rubber or other elastic packing A delivery tube is also attached, as shown in the cut, and descends nearly to the bottom, while communication is made by means of a small orifice at the top, between the interior of the glass vessel and the space between it and the exterior shell. By this means the pressure is equilibriated on the glass vessel, and is wholly sustained by the exterior case.

The advantages of this arrangement for beverages under pressure, which are to be kept on hand for a long time, are too obvious to need comment. We will only remark, that a large number of these fountains are in successful operation.

Quincy Railroad Bridge across the Mississippi in Illinois. We see, in the *Chicago Tribune*, an account of the opening of this bridge, which was tested and examined by the Engineers, Directors and others, on the 7th of November. We subjoin the following

account of this work, for which we are indebted to the above journal.

The Bridge Company was organized on the 20th of November, 1866, by the amalgamation of two incorporated companies, one chartered by the General Assembly of Illinois, and the other by the Legislature of Missouri. It took the name of the "Quincy Railroad Bridge Company." Nathaniel Bushnell, of Quincy, was made President; James F. Joy, of Detroit, Managing Director; C. A. Savage, of Quincy, Secretary; A. T. Hall, of Chicago, Treasurer; N. Flagg, of Quincy, General Agent; J. L. Lathrop, of Hannibal, Auditor; W. Colbern, of Toledo, Consulting Engineer; and T. C. Clarke, of Chicago, Chief Engineer.

Surveys were made, the bridge located at once, and the work commenced. The main bridge, that which spans the main branch of the river, consists of two draw spans, 160 feet each, making the length of the draws, or rather, swing, 360 feet. Two spans of 250 feet, three of 200, and eleven of 157 each, making a total, with the mason-work, of 3,250, constitute the main bridge. The embankments and trestle-work between are, 1,400 feet in length; bay bridge, 613 feet; one draw, 190 feet long; and four spans of 85 feet each. Total length of the bridge and embankments, from the Chicago, Burlington and Quincy to the St. Joseph tracks, nearly two miles. The bridge is elevated ten feet above high-water mark, and twenty feet above low-water mark, on stone piers, the stone coming from Grafton, Mo., and Hamilton, Ill. The superstructure is entirely of iron, and on the Pratt truss principle. The masonry and foundations are the work of the Bridge Company, under the immediate direction of T. C. Clarke, Esq., Chief Engineer. The total cost of the bridge is $1,500,000. The bridge is so proportioned that a train of two locomotives and the heaviest freight cars strain the iron only about 7,500 pounds to the inch, while its ultimate strength is 60,000 pounds to the square inch. Strength, before any permanent stretch begins to be seen, 28,000 pounds to the square inch. Every piece of wrought iron in the ties, links, bolts, &c., was tested in a hydraulic press up to 23,600 pounds to the square inch, and struck with a hammer, while under tension, before being used in the bridge. The first stone of the structure was laid September 25th, 1867, and the last stone August 5th, 1868. It was opened for traffic November 7th, 1868. The season of 1867 was such as to prevent the commencement of the foundation before

September, 1867. It should have been begun in June of that year.

On the occasion of the above-mentioned testing and examination of the bridge, a report was drawn up and signed by the various engineers present, and this we here quote in full.

"QUINCY, *November 7th*, 1868.

"The railroad bridge over the Mississippi, at this place, is now completed, and will be put in use for freight and passengers on Monday next. It has been, to-day, subjected, in the presence of a party of engineers and others, to various tests, the results of which are as follows: Three of the heaviest locomotives were coupled and placed at rest centrally upon the span 250 feet long, and the deflection or yielding of the bridge very accurately observed by means of instruments. The total weight of the load was 300,000 pounds, and the maximum deflection at the centre of the span was 2·4223 inches, being one-sixteenth of an inch less than the deflection previously calculated.

"The same load was then placed upon a span 157 feet long, and a deflection produced of 1·375 inches, which varied but little from the result of previous calculations.

"The three locomotives, still coupled, were then run over the 157 feet span several times, at rates of speed varying from ten to sixteen miles per hour. The deflection produced was 1·406 inches, being an increase of only 0·3 inch over the deflection while at rest. Probably no severer strain than the above will ever be applied to the bridge in actual use. In each case, on the removal of the load, the bridge at once resumed its previous form.

"A few words of explanation of the above experiments may be interesting to the public. Short of the dangerous and expensive process of actually breaking down a bridge by the weight equal to its ultimate strength, the only method of proving its safety is to measure the deflections produced by stationary or running loads. If these do not exceed the deflections, calculated as due to the known elasticity of the material, it may be safely inferred that the bridge is free from dangerous defects, either in material or workmanship. The strain applied to-day was 10,000 pounds to the square inch of wrought iron, and 5,800 pounds per square inch of cast iron.

"On the 157 feet span, the strain applied was 9,000 pounds per

square inch on the wrought iron, and 10,200 pounds to the square inch on cast, being about one-quarter more than the strain produced by the passage of the heaviest freight trains. All the wrought iron had been tested, before being used, by a strain of 23,000 pounds per square inch. Specimens of the wrought iron which were subjected to the ultimate strain, broke only at from 60,000 to 80,000 pounds per square inch. C. Shaled Smith, St. Charles Bridge; O. Chanute, Kansas City Bridge; J. E. Ainsworth, Dubuque Bridge; R. H. Temple, St. Charles Bridge; J. B. Moulton, North Missouri Railroad; D. C. Janne, Keokuk Canal; G. H. Morison, Kansas City Bridge; G. H. Nettle, Chief Engineer H. and St. Jo. R. R."

A Round-About Railroad(?)—In looking over an article on the Locomotives of the New Jersey Railway, published in the *Engineer*, (London) for October 16th, we were quite surprised to discover a peculiarity in the alignment of that road that we were not before aware of. The article states: "That whatever English engineers may think of the general design of these engines, it cannot be denied that they work well over bad roads. They work, for example, at high speeds, round *one stretch*, almost a *continuous curve* $11\frac{3}{4}$ miles long, the radius varying from 550 feet to 1,500 feet, with a steady rise." Now, taking the radius of 1,500 feet, the engine would move in a complete circle in every $1\frac{785}{1000}$ miles, and the line would double on itself a little over six times in a distance of $11\frac{3}{4}$ miles. We have travelled this line many times, and must confess to great want of powers of observation, that we should be obliged to depend upon an English journal for this important information. We shall take particular pains to notice it on our next trip. New Jersey may well be proud of her modern Tower of Babel. May her sands never overwhelm it, as did the sands of Asia her ancient representative. J. M. W.

Friction Clutch Pulley.—By Brown & Sharpe Manufacturing Company. A friction pulley that will operate with certainty, and without noise, that will continue to operate well, even after it has experienced the necessary wear of long-continued use, and which is not liable to derangement, by which work is delayed, and time lost, is a most desirable acquisition.

From the testimony of many machinists in this city, and also from an examination of the principle and construction of the apparatus named above, we believe that it fulfils the desired conditions in a very desirable manner.

The merits of this instrument will, we think, be evident from the following description of its structure.

Fig. 1. Fig. 2.

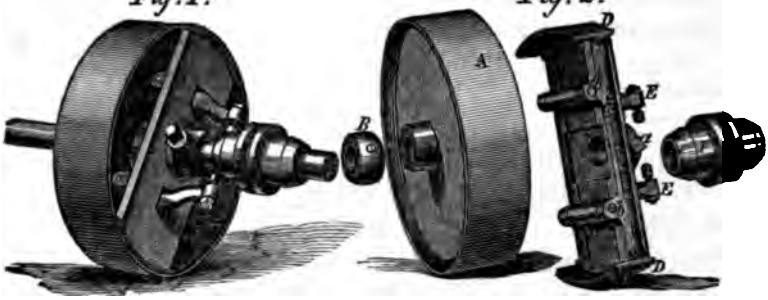
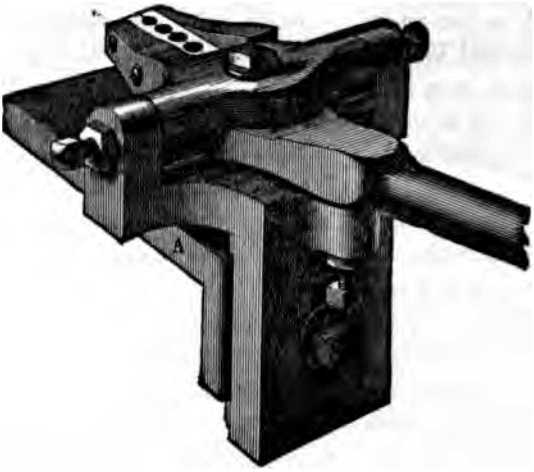


Fig. 1 represents a complete Friction Clutch Pulley in working position upon a shaft. Fig. 2 represents the parts of the same; A is a pulley, the inside surface of the rim of which is turned. This pulley revolves freely upon the shaft, and is kept in position on one side by the collar, B, and on the other by the segment plate, C. The segment plate, C, is fastened to the shaft by the set screw, *a.* Attached to this plate, and sliding in planed grooves, are two segments, D D, which move in opposite directions, at right angles, to the shaft. The outer surfaces of these segments are turned to the same diameter as the inside of the rim of the pulley, A. The two levers, E E, are connected to the segment plate, C, by pins passing through them and the ears, *b b*, which act as fulcrums. These levers pass through and are fitted to the segments, D D, and also through the segment plate, C. In the outer ends of these levers are adjusting screws with set nuts. Fitted to and sliding upon the shaft is a thimble, F, the end of which is turned of a conical shape. Upon the outside of this thimble is a groove into which a shipping fork is fitted. It will be readily seen that when the thimble is pressed forward, toward the pulley, the conical end comes in contact with the rounded heads of the adjusting screws, by which the two levers, E E, are forced outward, carrying the two segments, D D, which movement brings the faces of these segments into contact with the inside of the rim of the pulley, binding the surfaces together, and thus communicating the motion of the pulley to the shaft. This pulley is perfectly noiseless as well as simple and efficient, with no liability of locking or unlocking, except at the will of the operator.

Screw Slotting Machine.—By Brown & Sharpe Manufacturing Company. Quite an extensive machine is often used by gunmakers and others for slotting the heads of screws, but the device shown below, which can be attached to an ordinary hand-lathe, is believed to be more efficient for the purpose than any machine heretofore made. A single bolt fastens the platform, A, of this apparatus to



the bed of a hand-lathe, the long lever projecting in front at a right angle with the bed. An arbor carrying a circular cutter is held in the centres of the lathe. The long lever is moved horizontally to open the jaws for inserting and removing the screws, and downward to bring the screw to be slotted against the saw. A stop-screw, B, governs its downward motion, and thus regulates the depth of slot in the screw-head. The working part of the apparatus can be raised or lowered on the platform front by means of the bolt, C.

Erricson's Solar Engine.—As various eroneous expositions of the results reached by Mr. Erricson in the new direction to which he has of late turned his attention have been published, we take occasion to give the substance of what he has himself enunciated in the Stockholm *Aftenbladet.*

He says that by concentrating the sun's rays with apparatus which he has not space to describe, and applying the heat so developed to steam and air engines of special construction, an amount of force can be obtained, which may be thus expressed. The accumulated solar radiation which falls upon a space 10 feet square or 100 square feet in area, can develop more than one horse-power.

This area is, of course, perpendicular to the direction of the rays.

The sun-heat wasted on the roofs of Philadelphia would operate 5,000 steam engines of 20 horse-power each, while the sun shone.

The area of one Sweedish square mile (=49 English), if only half covered with sun machines, would develop force enough for 64,800 steam engines of 100 horse-power each.

At the surface of the sun an area of 10 square feet must emit heat enough to run an engine of 45,984 horse-power.

A Tangential Water Wheel, or Turbine, with partial admission, has lately been constructed by Messrs. Gwynne & Co., London, to take the place of one which had become useless through age, but which was originally set up by the Moors, at Molino del Rey, near Granada, in Spain. The culvert which conveyed the water to the wheel, the wheel-pit and the tail-race, were all cut in the solid granite, the entire work indicating great skill and judgment on the part of the original constructors.

In the wheel now introduced, the water is admitted to about one-quarter of the circumference by nine guide-buckets, which may be closed, one after another, by a valve which forms part of a circle and moves in guides cast on the casing. By this means provision is made for utilizing the very variable water supply which exists at this place, without loss of useful effect. From 1½ to 12 horse-power can be obtained, according to the quantity of water that may be found.

Water inclosed in Glass.—At the last meeting of the Institute there was presented by Mr. James Gaffield, of Boston, a piece of glass, being the head of a stopper containing water in its interior cavity. This was one of a large number of similar specimens found after a fire in which a great quantity of like objects had been destroyed, and resulted from the cracking of the heated glass by the water thrown on the ruins, the entrance of the water as the object cooled, and subsequent closing of the fissure, which in this and other cases was hardly perceptible, and entirely precluded the egress of the water.

Editorial Correspondence.

CORNISH PUMPING-ENGINES.

MR. EDITOR:—In looking over the October number of *The Journal of the Franklin Institute*, I was somewhat surprised to find, from the communication of Mr. W. H. G. West, that my eulogy of the Cornish engine, for pumping purposes, had only proved, that the rotative engine was equally good, or perhaps better. This certainly was not what I intended. But as Mr. W. has been kind enough to point out the more prominent errors contained in the article referred to, an opportunity will be thus afforded me for making any necessary corrections.

The grand question, as I understand it, is whether the operation of pumping water be better accomplished by the direct, unfettered action of a certain pressure, or by the secondary action of the same pressure, shackled by the incongruous addition of a revolving shaft? In case this question is of too abstruse a nature, it may be put in a plainer form, by substituting the analogous one, as to whether the shortest route between two points diametrically opposite each other, on the circumference of a circle, be by proceeding round the periphery, or by going straight across? Perhaps I may be biassed in my opinion, believing as I do in the direct path, and will therefore not enforce again my peculiar views at this time, but will leave it to the readers of this *Journal* to decide this seemingly difficult question. Turning my attention to the minor points in the case, as prominently brought forward by Mr. W., I find, that having at one place, recommended a uniform speed of piston for pumping water, I have afterwards acknowledged that the speed of the piston, at the time it is *not* pumping water, is uniformly accelerated, *i. e.* making the in-door stroke. The next is a direct question. "If, in the Cornish engine, the momentum acquired, together with the force given out by the expanding steam, carries the piston to the end of its stroke, does not the *vis viva*, or potential energy stored up in the moving parts of the rotative engine, together with the expanding steam, carry the piston of that engine to the end of its stroke, and does not the *steam* perform the *whole* work in either case?" Certainly the *steam* performs the *whole* work in either case. But it is by no means evident that the *steam* or the *whole* work is the same in both cases, as I shall hereafter, perhaps, be able to show. Again: "The

Cornish engine passes through the steam stroke very rapidly. If the pressure at the end of the stroke equalled the resistance, the *vis viva* of the moving parts would shoot the piston through the cylinder head, unless prevented by the catches." That depends upon the manner in which the engine is operated. There is no doubt, if it were driven in the same manner as found necessary for rotative engines, such a catastrophe would, if possible, occur at every stroke. And herein lies one of the chief points of merit, characteristic of the Cornish engine, for it is a known fact, that when the piston reaches the end of its stroke, the force of the steam is not sufficient to balance the weight of the heavy pump plunger, which has been carried onward solely by the *vis viva* stored up in the weighty moving parts. It is by the paying back of this amount of power, borrowed at a time of superabundance, that the pressure is made to coincide with the resistance,—balancing the account at every stroke. It is the duty of the engineer to see that this is properly done without premonition from the catches.

"Mr. H. gives us this same thing as a fault in the numerous direct acting steam pumps, and in these words: 'the terminal pressure must invariably be fully equal to the load, or the pump will come to a dead stand.' Now why will not momentum help this unfortunate engine as well as the Cornish engine? It will. Mr. H. knows it, and is convinced, too, that the terminal pressure need be no more equal to the full load in one machine than another."

In this, I am afraid Mr. W. has paid me an undeserved compliment, as I cannot recall to mind having been possessed, at any time, with the knowledge of the facts attributed to me. One reason I remember to have had, why momentum would not help the unfortunate class of engines alluded to, was, that because being horizontal, they were not quite so vertical as the Cornish engine, and that the laws of gravity did not act upon each precisely alike. I probably held an opinion, in regard to the unfortunate machines, that the principal effect of the laws of gravitation, in their case, was to produce friction, which occurred to me as being somewhat antagonistic to inertia. From an extended experience in the premises, I have invariably found that when the pressure on the steam piston is permitted to become less than the load on the water-piston, at that particular instant, such pumps come to a dead stand, no effect from *vis viva* being at all discernible.

"On page 31, we find that the plunger descends with a uniformly augmented velocity, and the momentum acquired is again stored up

at the end of the stroke, in the steam contained above the piston, to be made available in the return stroke. The piston, and *therefore* the plunger, *cannot* descend in this manner, for it is brought up by cushioned steam, just as that of the rotative engine is, and the velocity of each piston varies from full speed to a stand still at each end. Where is the difference, and what ill effect would it have upon the engine, if Mr. Henderson's statement *were* correct?"

"The fly-wheel would give back all the momentum, or *vis viva* imparted to it, but the steam would not, in any engine."

In regard to the piston, Mr. W. is perfectly correct; it *cannot* descend in the manner described, as at that time it is going up. The equilibrium valve, however, *descends* before the plunger has completed its stroke, shutting in a quantity of steam, above the piston, which being compressed by the continued descent of the plunger, the augmented force is transmitted from the one to the other, to be made available in the return-stroke, as previously stated. The *difference* between this mode of action and that allowable in the rotative engine, *when applied to pumping water*, is very marked indeed. There are several reasons why that engine would not work so advantageously with the same amount of cushion. In the first place, it would not work at all, for it would be found in practice, that not until this cushion had been mainly got rid of, would the engine ever be persuaded to pass its centres; as every person who has ever tried that experiment, or the kindred one of giving lead to the valve, has invariably discovered.

In regard to the fly-wheel giving back all the momentum or *vis viva* imparted to it, Mr. W. is again correct; it unquestionably will give back all that has been imparted to it. But unfortunately for that valuable appendage, its share of the *vis viva* is but a limited per centage; for the bulk of it will be saddled upon the crank-pin, to be distributed through the journals to the pillow-blocks, thence to the bed-plate, until it is finally lost in the very foundation of the engine. A very simple method of arriving at the truth of this axiom, would be to take off the pillow-block caps of any engine, where they are bolted on in a line with the direction of the stroke. Of course, if the *vis viva* be imparted to the fly-wheel, the centrifugal and centripetal forces balancing each other, this can be done without any risk?

"Will Mr. H. call to mind that we find in general practice, much higher steam used in rotative engines than in the Cornish, and will he favor us with an estimate of the amount of power, in steam, lost

by this variable speed in any engine? None, I think. "Upon investigation, I find that from sixty to seventy pounds of steam is not an unusual pressure used in the Cornish engine, where a high degree of expansion is employed. Quite a high pressure for large condensing engines; it is questionable whether it would be politic to imitate it in the rotative engine, which cannot yield to any of the extreme variations of steam pressure, to which the piston is constantly subjected, owing to the obstinacy of the fly-wheel; the amount of power lost, in consequence, is, strictly speaking, that amount of *vis viva* which is expended upon the crank-pin at each alternate stroke. It will vary with the pressure of steam employed, the point of cut-off, and the load. The only reliable, or practicable way to estimate it, would be to erect two engines, of the same calculated cylinder capacity; one a Cornish, and the other a rotative pumping engine; the extra amount of work performed, with an equal quantity of fuel, by the former engine, would represent exactly the amount of power lost. That it is something considerable, may be ascertained in a more simple manner, by constructing a rough model of the working parts of a steam engine, and operating it by turning a crank by hand; then attach a sliding weight of the same gravity as the moving parts, to a return-crank proceeding from the end of the crank-pin, giving the same throw as the crank, in the adverse direction, so that when the piston is moving in one direction, this counter-weight will be moved diametrically in the opposite; then by turning the crank again, it will be at once very apparent that considerably less power is required than before. In the former case, the amount of *vis viva* parted with at each dead point, if the machine be run at a high rate of speed, is so great that it would be difficult to hold it, to test the experiment; while in the latter case, it will stand as steadily as though it were not under operation. This information I have from actual experiment.

"No *serious evil* effects can result from increasing the speed of the plunger near the middle and *towards the end of the stroke*, for when the water is put in motion, the plunger may move faster. Were the steam shut off, the *vis viva* of the moving water would carry the engine some distance with it, and the speed may, therefore, increase without loss, keeping the pressure against the plunger uniform. There is no loss here from variation of speed, except by friction; frictional resistance varies as the square of the speed, at low speeds, but as a *higher power at higher velocities;* and as the Cornish engine comes in like a rocket when it takes steam, we may

infer that it is the least economical of engines, as far as that *serious quality* is concerned."

Mr. W. is unfortunate in his selections for criticism, and certainly does not manifest any remarkable merit as a *careful reader*, personally, for it will be observed, the *serious quality* here complained of, has no existence in fact; for at the time selected, the pump is only taking water, and *no pumping* is being done. The rocket principle, on the contrary, is a manifest advantage, for the quicker the plunger is lifted, the oftener will it descend in a given time. This principle of variable velocity is also used with eminent advantage on the planing machines used in machine shops. The pressure against the plunger is the constant area of it; multiplied by the head, and by the *velocity*, it would not be safe to calculate upon any assistance from the *vis viva* of the moving water, under the circumstances stated. Pumping water is very unlike driving rotating machinery, which will continue to run some time after the steam is shut off from the engine; under the same operation, a pumping engine stops momentarily.

"We now pass to the saving of steam from loss by clearance and steam passages, and the isolation of the working end of the steam cylinder from the cooling influence of the condenser. Isolation in this case, means a high degree of expansion, or very high temperature to very low temperature, during the in-door stroke; then this low temperature, very little above that of the condenser *to* both sides of the piston during the out-door stroke; then exposure of all the cylinder but about a foot of the out-door end, to this same temperature; and last, the exposure on the lower side, during the in-door stroke, tó the cooling influence of the condenser. This is saving by isolation with a vengeance. It is very well known that the pistons of Cornish engines, perfectly tight at one end, leak badly at the other, when the cylinder has no casing, or when the casing is cold."

The meaning of the term "isolation," in its application to the Cornish engine, as rendered by Mr. W., fortunately cannot overcome the incontrovertible fact, that however much of that engine is exposed to the frigorific influence of the condenser, there is twice as much exposed in the rotative engine; the one being *single*, and the other *double* acting. It is not necessary to multiply words over such a palpable theorem, nor is it of any consequence to ascertain by what mode of calculation it can be made to appear that less than the half is greater than the whole, or that 2 and 2 being four, 1 and 1

[illegible]

[illegible] pay. [illegible] evaporating [illegible] reaches [illegible]

[illegible] controversy [illegible] public, [illegible] Mr. West and myself that as he [illegible] his assertion [illegible] as good duty as the best Cornish engine (page 2[illegible]), to produce one to compare in efficiency with the celebrated Fowey Consols experiments, where a duty of 130 millions of pounds of water was raised (by a Cornish engine) one foot high, by the consumption of 112 pounds of coal, *vide London Engineer*, July 17, 1866.

W. M. HENDERSON,
Hydraulic Engineer.

Philadelphia, November 14, 1868.

Civil and Mechanical Engineering.

BLASTING WITH NITRO-GLYCERINE AT THE HOOSAC TUNNEL.

WE have been in hopes of giving our readers before this a full account of operations in the above direction, from the pen of Mr. Geo. M. Mowbray, who has been engaged both at the Hoosac Tunnel and elsewhere in the manufacture and use of this efficient explosive. Excessive press of business has, however, as yet prevented Mr. Mowbray from fulfilling his promise to us, though he assures us of a speedy supply, and, in the meantime, sends us the following extract from the *North Adams Transcript*, which, though not very precise and formal in its style, will, nevertheless, possess great interest for our readers, and will make up, by the vividness of its description, for any fault of form.

Monday, March 2, A. D. 1868, ushered in a snowing, gusty day; the wind, during the preceding night, had been urging puffs of snow, dry and crystalline, through every cranny of the mountain shanty, before whose soapstone stove I had been warming my rheumatic limbs; and, since travel seemed impracticable, I made a virtue of necessity, and accepted an invitation from my host to descend the west shaft of the Hoosac Tunnel, where the temperature, 60° F., would at least be more agreeable than on the mountain side, where the thermometer was then 6° below zero.

So, donning a miner's suit, rubber boots, Cape Ann oilskin jacket and southeaster, we stalked through the deep drifts of snow, and at 7, A. M., I found myself standing on the cage that is used for lowering and hoisting in the shaft, beside two pails, each having an inner lining of plate tin, with cover, suitable enough, as it seemed to me, to carry down hot coffee for the miners. These pails, and a conductor's lantern, were in charge of a man equipped in miner's costume, similar to our own, who was exchanging remarks with the topman, whose duty it is to signal the movements of the hoisting apparatus.

A gong sounding, we began to descend rapidly, or rather, as it seemed to me, the shaft began to rise around us in a most alarming manner.

The cold air of the outer world, descending and mixing with the

warm, saturated air rising from the tunnel, caused a vapor that rendered the light of the miner's lantern scarcely visible at two paces distance. It is an unpleasant position for a stranger to be in, going down, down, down, with streams of condensed vapor pattering on the head, neck and shoulders; and to relieve the monotony and suspense of the descent, I addressed myself to that man with the "hot coffee" pails.

"By the way, I thought I caught the word 'glycerine' spoken by that man who let us down."

"Possibly."

"Have they ever used nitro-glycerine in this tunnel? I mean that terrible explosive agent, which tears everything to atoms. I should like to see some of it, and know all about it; it would give one a sensation that would relieve a fellow of this—this oppressive feeling."

My companion deliberately lifted the cover of his pail, and taking thence an open slender tube, which seemed to contain clear water, said:

"There it is."

"What! Good —, in this cage? Do you mean to say we are boxed up in this hole with— ?'"

"Yes," returning his tin cylinder to the pail, and replacing the tin cover, "that is nitro-glycerine—one of twenty cartridges we are about to use in blasting."

I reflected; here I was, in a box four feet by three feet, no escape from a pail containing enough nitro-glycerine to send us up that shaft, and into eternity for the matter of that, and I had been confounding the "perilous stuff" with hot coffee. There was no help for it now, and as the heavy beat of the steam pumps and warm temperature rendered conversation difficult, I certainly felt as if I had put my foot into it, or something like it.

But we are at the bottom of the shaft.

"Stand clear there, glycerine!"

"All right, sir."

"Where's our car?"

"Here, ready; can I help you?"

"Only by keeping clear with your flaring lamps; push on."

And now, impelled by a brakeman, our car is rapidly driven to a small caboose, or cupboard, some three hundred yards from the shaft, the trip relieved by an inquiry:

"How is it the water's so high?"

"A pump gave out last night; water's been gaining since; the machinists will soon fix it."

My companion now unlocked the door of this little caboose on the left side of the tunnel, examined briefly the signal apparatus, an electro-magnet and gong, then the switch or brake, which turns off the current from the wires leading to the heading, and assures himself that whilst charging the drill-holes, no electric spark can pass over the wires by any tampering with the instrument above ground; this done, he resumed the pails, and we now rapidly pushed on to the heading, about one hundred yards distant, the way enlivened by a gushing spring of water; ascended the two benches of rock, we now came upon twelve miners, each with his candle, and the foreman busy examining the finished drill-holes.

"Mr. Gregory, will you send your men back?"

"All hands back from the heading! Glycerine, lads! Pick up your tools; hurry up there, and mind you don't run foul of this man!"

"Where are your holes?"

"Here they are, good and strong."

Eighteen holes are now counted, their diameter and depth gauged; these are found to vary from twenty-six to thirty-two inches in depth, and at various angles, and in various directions from the face, each of them being capable of receiving a cartridge eleven inches long, and one and one-fourth in diameter.

"You need not stay, foreman."

"I'se no fear; I'll just help a bit. Don't mind me; I seen glycerine afore."

Carefully and deliberately a cartridge is removed from the pail; an insulated wire, with priming, exploder, and cork attached thereto, closes the open mouth of the tin cartridge, and still more carefully the cartridge, with its mischievous little wire and fulminating exploder, is now passed into the drill-hole, and pressed down to the extreme end, leaving the wire pendant therefrom like a rat's tail; when this performance has taken place in eighteen holes, a count is made—eighteen.

Now the conducting main wire is brought forward and attached to one of these pendant wires, which, by the way, on close examination, consists of two wires, when attached to one of these, the other is carried to one of the double wires of the next hole, until

each of the eighteen holes is linked with the one next to it, and that to the next, forming a series of links, the first connected with the conducting, the latter with the return wire.

Then two wires, when the switch or break is suitably disposed, connect the cartridges in the holes with the electrical machine, 1,500 feet distant above ground, in the timekeeper's office.

Now, bear in mind, there is a break one-tenth of an inch from each other, of the points of the wires in each hole, and this break is armed with a sensitive priming, so that the electric spark, as it leaps from one wire to the other, ignites it; this fires a fulminate, and the explosion of this fulminate explodes the nitro-glycerine, and the nitro-glycerine plays the — with the stubborn, tough, solid rock.

But my mining friend is scrutinizing every connection, and now he counts every hole; none have been missed.

"All back!"

We now turn our backs (with a very satisfactory shrug on my part,) on the masses of rock, burrowed with the eighteen drill-holes, each charged with sufficient nitro-glycerine to hurl it into fragments, aye, from the very bottom of these holes, and to send a blast of liberated gases that will hurl a puff of steam and air out of the shaft 1,500 feet distant.

That pail, I perceive, our companion carries with him. We descend the first bench; at the second he deposits his pail, and we all hurry back to the caboose, where the miner's lights, like the *ignis fatui*, seem right welcome.

But where is there a recess, a safe recess, where I may avoid the consequences of my curiosity? Narrowly watching the miners, I am aroused by the inquiry, sharp and quick in tone:

"All back away from the heading?"

"All back."

"Look out for yourselves!"

And then our sober, decided friend enters the caboose; the door is locked; the miners converse; I endeavor to secure a position by which a good number of miners are between me and that heading, and sit me down on an iron pipe, which, Mr. Gregory informs me, is to supply air to the machine drills.

"Look out, now!"

Instantly, I notice the miners carry their hands to their ears; instinctively I follow suit; the hum of conversation has ceased; a

dead silence succeeds; the pulsation of the steam pump throbs; the breath comes quick;—oh, this suspense—a singular exaltation or excitement thrills through one.

"Boom—oom—ooom!"

A rush of air—my hat has gone with it; pitch dark, for every light and lantern is extinguished.

"Who's got a match?—no one, I bet."

"Yes; here's one."

"A heavy blast, that; she got it that time."

And now the foreman, our companion and myself, make for the heading; the miners are told to keep back.

We return to where the ingenious arrangement of wires, aided by the electric machine, above ground, has effected this discharge.

As we approach within fifty feet of the heading, a warm, sweetish vapor is looming up; still on, on, on: here is a mass of rock; move carefully, there may have been a cartridge thrown out unexploded, laying at your feet. If so, don't trample on it, that's all.

Scrambling over the masses of torn, broken rock, the heading is at last reached—ragged, indented, a scarred witness of the tremendous power of nitro-glycerine.

After carefully noting that each and every hole has been blown out, we return towards the miners. At the second bench, our friend picks up his pail, and assures himself of the safety of the two remaining cartridges.

We soon come to the miners; the word is passed, all safe; another foreman takes in his gang for another eighteen holes, to be drilled in eight hours, the time allotted for each shaft, and pushed back to the shaft, the truck running into the cage.

Signal being given, we commence our ascent—or, better described, now the shaft rushes down, down, down past us.

Daylight once again, and the pleasant warmth of the tunnel is exchanged for the sharp, keen north wind, and 6° below zero temperature. We follow the man with the pails, over the drifting snow, to a shanty, where a good breakfast, hot and glowing fire, await him.

"Breakfast ready, Hoecake?"

"All ready. Blast go off all right, sah?"

"Made two feet heading--hurry up that coffee."

"What do you think of blasting, Mr. —?"

"Well, I think it gives a fellow a sort, of a kind of—new sensation, decidedly."

BELTING FACTS AND FIGURES NO. II.

BY J. H. COOPER.

(Continued from page 326)

Side of Leather to Pulleys.

"EXPERIENCE has adduced the fact that when the grain side of a belt is placed next to a pulley, it will drive about 34 per cent. more than when the flesh side is placed next to it."—W. B. in *Sci. Amer.*, March, 1860, p. 150.

"It is pretty generally admitted that leather belts placed with the *grain* side next the pulleys will carry more power; but in connection with this another question arises, namely, *which side placed next the pulley is most durable?*"—*Sci. Amer.*, March, 1860, p. 197.

"Every one knows that the strength of belt leather is on the hair side, and it may be said to lie in about one-fourth the thickness; it is evident then, when that part of the belt is worn away it is no longer of much service."

"I give the flesh side a good coat of tanner's dubbing. I repeat this two or three times in as many days. By this treatment the pores of the leather become filled and the flesh side acquires a smoothness equal to that of the hair side, and my experience has taught me that belts will last six times longer when used in this way than when run on the hair side exclusively."

"This is my experience of twenty years with belts, and when I have treated my leather in the same manner, the same results have always been secured."

"I would be in favor of putting the smooth surface of belts next the pulleys, were it not that they are much more durable when the strong side is kept from wearing."—T. McG., Jr., in *Sci. Amer.*, March, 1860, p. 197.

"The wearing of belts depends altogether upon circumstances. If they adhere well to the pulleys and there is no slipping, but a continual adhesion while at work, leaving the pulleys clear, there is no perceptible wear while running with the hair side to the pulley, but put the rough or flesh side to it, and the wearing of it will soon occur from friction caused by slipping on the pulleys."

"When belts run with the *hair* side next the pulleys, they drive 33 per cent. more machinery and run more steadily than when reversed."—D. I. in *Sci. Amer.*, June, 1860, p. 357.

"Belts rubbed over with neats' foot oil once a week, will give more regular speed, last double the time, and effect a great saving of leather, and experience has established the correctness of placing the smooth side of the belt, next the pulley."—H. M. in *Sci. Amer.*, July, 1848, p. 326.

Influence of the Thickness of Belts.

"When bent round the circumference of a wheel, the outer parts of the belt are distended, the inner parts relaxed; and supposing the section of the belt to be rectangular, the amount of force expended in making these changes is proportional directly to the breadth, to the square of the thickness, and inversely to the diameter of the wheel. Hence if two belts be of like strength, but the one broad and thin, the other narrow and thick, the amounts of force expended in bending them must be proportional directly to their thicknesses, and hence the advantage of using broad thin belts."

"The practice of strengthening belts by riveting on an additional layer must be exceedingly objectionable: indeed, it is difficult to see how any additional strength is gained, for the outer layer must be tight when on the wheel, and slack when free, so that in reality, the strength of only one layer can be available, the parts of the compound belt are puckered and opened alternately, as evinced by the crackling noise."

"The proper procedure is to increase the breadth of the belt."

"So far as we have yet seen, it is preferable to use heavy belts." *Prac. Mech. Journal*, November, 1866, p. 240.

Convexity of Pulleys.

Morin says: "The pulleys over which leather belts pass ought to have a convexity equal to about one-tenth of their breadth."

London *Mech. Mag.*, for March, 1863, says: "belt pulleys should be made slightly convex, in a ratio of half an inch per foot of breadth." Molesworth says the same.

Another proportion is $\frac{1}{8}$ inch wire in 8 inches of width. Still another $\frac{1}{8}$ inch to the foot.

"The rounding should be made as slight as is consistent with security, since every deviation from the cylindric form is accompanied by a loss of force."

"In their progress round the wheels, the different parts of the belt are stretched and relaxed alternately. Now, if the material were perfectly elastic, the force expended on the distension would be reproduced on the contraction of the belt, as the loss by this imperfect elasticity is not known, it will be enough to observe, for the present, that the loss of force will certainly be greater, the greater the disturbance of the particles—the higher the rounding of the pulleys."

Why a Belt runs to the higher part of a Pulley.

Much disputation has been published in efforts to solve the question: Why does a belt run to the higher part of a pulley? There may be several causes, but the chief one is embodied in the following words: That edge of the belt which is towards the larger end of the cone is more rapidly drawn than the other edge, in consequence of this, the advancing part of the belt is thrown in the direction of the larger part of the cone, which obliquity of advance towards the cone must lead the belt on its higher part.

"It may here be observed that this very provision, the rounding of the face of the pulley, which keeps the belt in its place, so long as the machinery is in proper action, tends to throw it off whenever the resistance becomes so great as to cause a slipping."

"To maintain a belt in position on a pulley it is necessary to have the advancing part in the plane of the wheel's rotation."

Running Conditions.

"The slack side on top with large pulleys at high speed, is undoubtedly the true philosophy of transmitting power by belts."

"Speed must not be gained before power in the use of belting. My first experience for myself was running a gang of twelve 7-inch saws and an 8½-inch trimmer, with a 4½-inch pulley."

"I had too much speed and my saws did not run with power to do the work. I then tried a 6-inch pulley, which did better; but still not being satisfied, I had a 7-inch iron one put on, which drove the saws with sufficient power to do all the work."—P. in *Sci. Amer.*, March 1860, p. 150.

"A belt adheres much better and is less liable to slip when at a quick speed than at a slow speed. Therefore, it is much better to gear a mill with small drums, and run them at a high velocity,

than with large drums, and to run them slower; and a mill thus geared costs less and has a much neater appearance, than with large heavy drums; and in belting, if the power of a belt 18 inches wide were required, it would be much better to put in two 9-inch belts than one so wide, owing to the greater inequalities of leather in such large pieces causing loss of adhesion."—I. H. B. in *Frank. Inst. Jour.*, June, 1837, p. 451.

"No belt should be worked up to its full power, and is best run with the slack side on the top and on large pulleys at high velocity, a long slack belt will work for years, but a short one, under heavy strain, is soon destroyed."—R. F. in *Sci. Amer.*, September, 1855, p. 14.

Long belts are preferred to short ones, but care must be taken that the length be not too great.

We have a case in point where a 60-inch pulley at 45 rev. per min. drove a 15-inch pulley, about 50 feet distant, by an 11-inch belt, 109 feet long. The tops of the pulleys were nearly on the same level, and the belt was crossed.

This belt was continually flapping about, soon became crooked and irregular in width and was frequently torn asunder at the lacings by excessive tension, and the whole arrangement proved very troublesome until changed to the following: The speed of the 60-inch, and the diameter of the driven pulley were doubled, and the distance between their centres was reduced to 15 feet. The belt now drives with more power, gives greater regularity of speed and works better every way.

Another case of excessive length, which has come under our notice, is that of an 11-inch open belt on a 4-foot pulley running horizontally at a speed of 2261 feet per minute over a 32-inch pulley, 30½ feet distant. To prevent surging, this belt must be drawn and laced very tightly; too much so for economical running.

Some facts illustrating the evils of short belts were given to me by a friend.

A 30-inch pulley, running 127 rev. per min., drove a 9-inch pulley by a 5-inch belt 14 feet long, the shafts were nearly in a horizontal plane and the lower fold of the belt did the driving.

To do a certain work this belt frequently slipped even when drawn very tightly, so much so, that it tore out at the lacings almost daily, and sometimes three times a day.

After much inconvenience it was changed for a belt 44 feet long;

the 9-inch pulley shaft being removed horizontally to accommodate the increased length, while all the other parts remained the same.

It now performs very satisfactorily; it does not slip, holds at the lacings and the slack fold above sometimes nearly touches the driving one beneath.

The 9-inch pulley shaft carries an 18-inch pulley, which, in its turn, drives a 7-inch pulley below on an Alden fan spindle.

Variation of Speed.

From experiments made, it has been ascertained that about two revolutions per hundred are lost in the transmission of motion by a belt. In ordinary practice this would be a slight loss, and would in no wise interfere with the usual manufacturing processes, but where there is a long train of gear repeated from shaft to shaft by belts, the loss becomes serious.

It is clear if the co-efficient of loss by slippage be ·98 for a single pair, which has been verified with great certainty by varying the tensions of the same belt, it will become equal to the successive powers: ·98, ·96, ·94, ·92, ·90, and so on; so that after a succession of five speeds the loss amounts to $\frac{1}{10}$th of the calculated speed, and that at the end of thirty-four speeds the velocity will be reduced to half.

From these considerations it appears that where it is required to transmit speeds as near determinate as may be, by means of bands and pulleys it is necessary to increase the diameter of the driving pulley by its fiftieth part, or diminish the driven pulley in the same ratio. See *Lond. Mech. Mag.*, March, 1863.

"I have found by experiment that if equal weights were suspended upon opposite sides of the same pulley, by straps of equal wt., but of unequal thickness, the wt. suspended by the thick strap would preponderate, and which seems evident from the consideration that the thick belt carries the wt. further from the centre of motion."—E. M. C. in *Sci. Amer.*, Jan., 1851, p. 142.

"Experiment has taught that ropes, belts, &c., in coiling around cylinders, or pulleys, stretch on the outer side and contract on the inner: the stretch being 2, and the contraction 1, consequently the point that neither stretches nor contracts is $\frac{1}{3}$ the thickness from the inside."—H. W. B. in *Sci. Amer.*, Feb., 1851, p. 158.

"I have always noticed in substituting a thick for a thin belt and *vice-versa*, particularly on machines where the calculations are

nice, that a change in the working of the machine always ensued. Some of our best and most practical manufacturers here, add the thickness of the belt to the diameter of the pulley."—E. B. M., Manchester, N. H., in *Sci. Amer.*, Feb., 1851, p. 174.

Speed.

The best speed for economy is 1000 to 1200 feet per minute, 1500 will do very well, but at 2000 feet per minute economy must be neglected."

"To get the best results from belts they should not be driven more than 1800 feet per minute.

"A leather belt ought to have a velocity of at least 1500 feet per minute, and not more than 2000 feet, or it does not last long.

Comparison of Flat with Round Belts.

The apparatus used for testing the comparative adhesion of good flat and round belting, the latter made under the patent of George Miller, granted in the year 1854, consisted of a horizontal shaft in fixed bearings, carrying a 12-inch pulley of over 3-inch face and a 12-inch wheel with groove ¼ inch deep, formed for receiving a ½ inch diameter round belt. Parallel to this shaft and 10 or 12 feet distant was arranged another shaft, with similar pulleys, turning in a sliding frame, carrying also another flat face 12-inch pulley.

A flat 3-inch belt, with *grained* side next the pulleys, on trial would not lift 87 pounds, which were suspended from the periphery of the other 12-inch pulley, a work doubly performed by the ½-inch round belt under the same tension. On the other hand, a tension of 174 pounds on the flat belt, applied to the sliding frame, was necessary to give it sufficient adhesion to lift the 87 pounds weight. It is, therefore, inferred that the round belt possesses an adhesive quality four times that of the flat belt, and must be more durable as the mean increases with the tension.

Experiments prove that ¼ inch round belt is more than equal to a 1 inch flat, and a ½ inch round more than a 3-inch flat. The economy of space and material, and diminished friction of journals are points of great importance to manufacturers.

Pulleys for round belts should have a V form not a U-shaped groove.

"These round belts are made by scarfing a broad belt, and rolling it up, not spirally, lengthwise, but in a horizontal fold, so as to

form a perfect round tube, with a very small central bore."—*Sci. Amer.*, April, 1859, p. 285.

Rubber Belting.

"A glazed face is just what I want on a rubber belt; you may be sure you have your belt in good working condition if the face polishes up smooth so as to shine. I have been running rubber belts for fourteen years and have now over 3000 feet of all widths from 2 feet to 2 inches, running in the factory with which I am connected, and I always want to see the faces smooth up and become glossy."

"There is considerable difference in these belts, even in the same lots, but those do best that polish on the face by use, provided they are at the same time flexible."

"I think it is a great mistake to have belts thick; to get power it is much better to add to the width, and never strain the belt too hard; then get your pulleys as smooth as possible, a very little swollen in the middle, say, $\frac{1}{8}$ inch to the foot in width. In starting a rubber belt, the dust should be first brushed off it; if it begins to polish, you may be sure you will have no trouble with it."

"Some of my neighbors use double leather belts which are very expensive; but for economy and keeping up a uniform speed, give me a rubber belt of liberal width, not too thick, but flexible. I have run such belts from three to five years without altering a lacing, and have now running some which have been in use from seven to ten years. There is another good thing in rubber belts; they keep tight on the edges. I have found it a good plan to lag pulleys with a piece of rubber belt; if fitted on neatly it makes a really good lagging."

"At Chickering & Sons' great piano factory, which is close by me, they run with rubber belts; their main belt and pulley are as smooth as glass. There is not in New England, better or neater adjusted machinery than theirs."—B. M. C., Roxbury, Mass., in *Sci. Amer.*, Nov., 1860, p. 294.

"A vulcanized india rubber belt will sustain a greater stress than leather, added to which its resistance to slipping is from 50 to 85 per cent. greater."

(To be continued.)

THE MANUFACTURE AND WEAR OF RAILS.

By Christer Peter Sandberg, Assoc. Inst. C. E.

In these times, when communication between different places is carried on mainly by the system of railways, it becomes important to determine the best mode of manufacturing railway bars, so as to obtain the greatest amount of wear, at the least possible cost.

As this question is one of increasing interest, the author has thought it might be profitable to communicate to the members of the Institution of Civil Engineers, the experience he has gained during the last six or seven years, while engaged in superintending the supply of rails to the three Scandinavian countries, Sweden, Norway and Denmark.

The paper will be divided into three parts. First, as to the best method of manufacturing rails out of common iron, and as to the time they will last. Secondly, as to the disposal of the iron rails when they are worn out; and thirdly, as to whether iron or steel, or a combination of the two materials, is the most economical to use for rails.

The mode of manufacturing rails for Sweden, as carried out in Wales, between the years 1856 to 1860, consisted in hammering the pile for the top slab after the first welding heat, and in rolling it after the second heat. It was supposed that hammering would produce a superior weld and a harder wearing surface, than could be obtained by rolling alone. This method was, however, gradually superseded at other works in England, and in Wales, during the period referred to, by rolling only.

Hammering the slab after the first welding heat entailed an additional charge of 20 per cent. per ton, it therefore became the duty of the Swedish Government to determine, by practical trials, whether the value of the finished rail was correspondingly increased.

With this object in view, several rails were rolled, and arrangements were made for putting them down, in such situations, on some of the English lines, as would expose them to severe wear. The experiments further aimed at discovering, if possible, how long the rails manufactured at the Crown Avon Works, in South Wales, and imported into Sweden, would resist the traffic of that country.

Five different kinds of "piles" were employed, twenty rails, of a

flange section, $4\frac{1}{2}$ inches deep, and weighing 62 pounds per yard, being rolled of each particular sort.

The mode of manufacture was as follows:

The rails marked **T** were made from a pile formed of No. 2, or welded iron, for the top and bottom, the rest of the pile being of No. 1 puddled bar iron. The top slab, and the squares next to it, were made from an hammered bloom of ordinary puddled iron, and filled in at the middle with crop ends, from top slabs and other pieces of No. 2 iron.

The rails marked **Y** were made from a pile of the same composition as that of the **T** rails, with the difference that the pile for the top slab consisted of puddled bars, without any welded iron pieces or crop ends being introduced in the middle of the pile.

The pile for the rails marked **H** was composed of a top slab made from puddled bars, hammered after the first heat, and rolled after the second heat, similar to the rails marked **Y**, the iron for the flange consisting of four pieces instead of eight.

The pile for the rails marked **E** was exactly similar to that for rails marked **H**, excepting that the pile for the top slabs was rolled after the first heat, as well as after the second heat. This difference in the mode of manufacture was adopted in order to discover whether, in this common iron, hammering improved the rail to a corresponding extent. Instead of No. 2 iron, puddled bars were chiefly used for the squares near the slab, and for the foot of the rail.

The pile for the rails marked **N** consisted of puddled bars, without any top slab.

All the rails passed through the rolling successfully, with the exception of the **N** rails, some of which showed cracks, owing to the inferior quality of the puddled bar.

The London and Northwestern Railway Company, being interested in this problem, allowed experiments to be made on their line, so far as the wear of these experimental rails was concerned. The experiments were carried out at Camden Town Station, where the rails could be better and more thoroughly tried than elsewhere; first, on account of the enormous traffic which obtains at that spot; secondly, from the constant shunting; and thirdly, owing to the grinding action of the engine-wheels in starting the trains. The result of these experiments is shown in a series of tables, drawn up

by Mr. H. Woodhouse, Superintendent of Permanent Way.—*See Appendix.*

The following Tables show the number of tons passed over each experimental rail before it was crushed, and also before it was taken out.

Mark of Rails.	Crushed.	Worn Out.
	Tons.	Tons.
T	3,680,000	5,060,000
Y	4,140,000	5,290,000
H	3,220,000	5,000,000
E	6,900,000	8,970,000
N	3,220,000	5,520,000

Another table, calculated from the preceding one, shows how long the rails will last, supposing them to be passed over by 3,000 trains yearly, each train being composed of an engine weighing 30 tons, and of 20 wagons of 10 tons each, or a gross load of 230 tons.

From these Tables it was ascertained that the five different descriptions of rails were, on the average, crushed in 6 years, and worn out in 9 years, thus:

T		Y		H		E		N	
Crushed.	Worn Out.	Crushed.	Worn Out.	Crushed.	Worn Out.	Crushed.	Worn Out.	Crushed.	Worn Out.
Years.	Years.	Years.	Years.	Years.	Years.	Years.	Years.	Years.	Years.
5	7	6	7	5	7	10	13	5	8

As the object of these experiments was chiefly to ascertain the difference between a rolled and a hammered slab, both made from inferior iron, **E** representing the former, and **H** the latter, those rails were placed so as to compare their relative resistance to wear

and the result shows the **E** rail, with the rolled slab, to be superior at each place where the rails were tested.

Among the other descriptions of rails, the **N** section endured the longest, although it had no top slab of No. 2 iron.

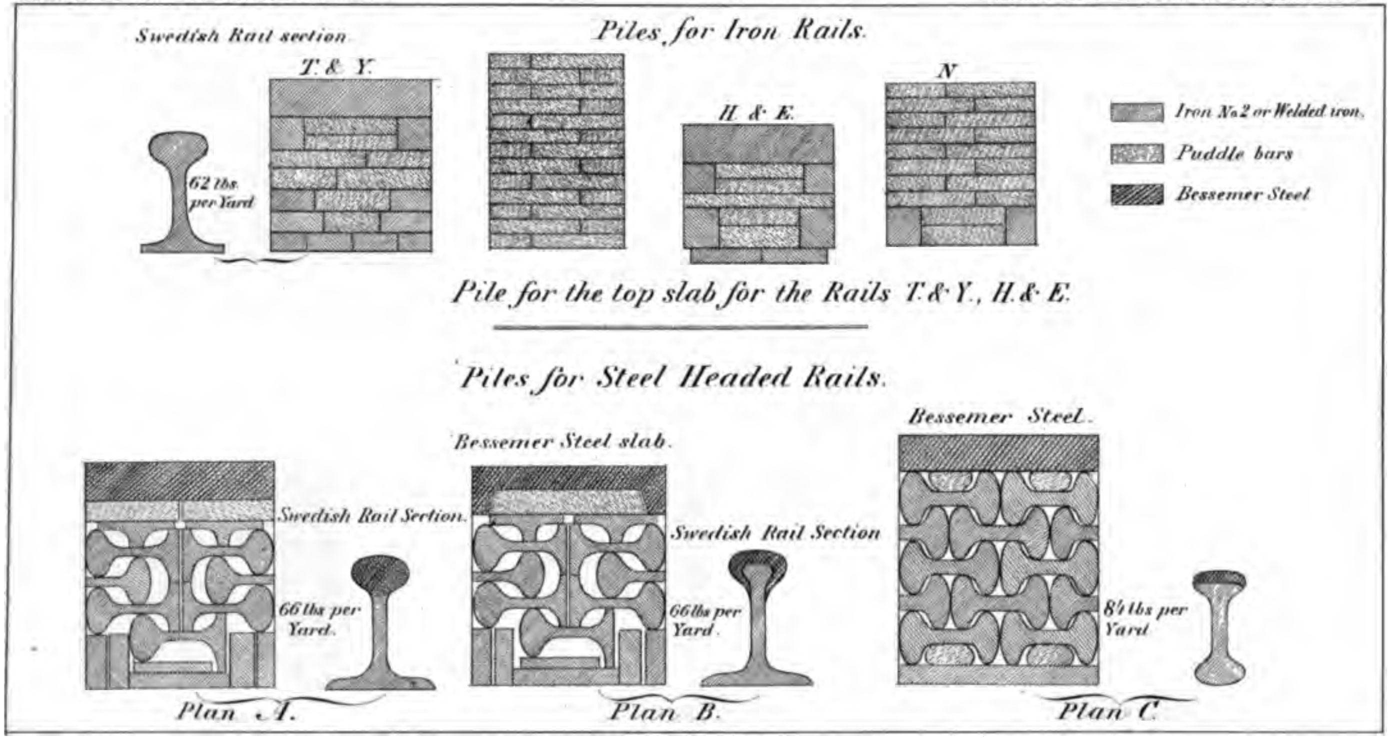
The conclusion is thus arrived at, that hammering after the first welding heat, for this particular kind of iron, does not improve the endurance of the rails, but that the simplest mode of manufacture has also the material advantage of being the best. These trials, at the same time, establish the fact, that it is not the wear or diminished sectional area, caused by abrasion, which produces the unsatisfactory results in the endurance of iron rails, but the lamination caused by imperfect welding. This explains the great difference in the result between the wear of rails made in exactly the same way, the welding in the one case being perfect, whilst in the other it has been very imperfect.

The results obtained at the Camden Town Station, however, are not applicable to the circumstances and conditions of the wear of rails which occurs under ordinary traffic, but rather to exceptionable situations, where the wear is occasioned, principally, by the frequent use of the breaks, and by continual shunting, in a much higher degree than at any other point of the line. These results may also be attributed, in part, to the great weight of the locomotives, in proportion to the weight of this particular section of rail.

Rails of the same dimensions, and of similar quality of iron to those marked **E**, have been tried on the Great Northern Railway, and have lasted during the passage of about 65,000 trains, of a total aggregate weight of 13,000,000 tons, one-fourth part of this traffic being at a speed of about forty English miles per hour, and the remaining three-fourths of fifteen miles an hour.

These experiments confirm the rule laid down in Mr. R. Price Williams's paper "On the Maintenance of Permanent Way," viz: that the endurance of rails may be measured by the product of the speed and of the passing weight. The trial rails on the Great Northern Railway may thus be said to have borne 276,000,000 tons, at a speed of one mile per hour. The endurance of the rails tried at Camden Town, under such unusual circumstances, is much less, and may be represented by 120,000,000 tons at a speed of one mile per hour.

Another mode of arriving at a judgment as to the endurance of these rails on the Swedish State Lines, is found in the renewals


Piles for Iron Rails.
Swedish Rail section
62 lbs. per Yard
T. & Y.
H. & E.
N
Iron No. 2 or Welded iron.
Puddle bars
Bessemer Steel
Pile for the top slab for the Rails T. & Y., H. & E.
Piles for Steel Headed Rails.
Swedish Rail Section.
66 lbs per Yard.
Plan A.
Bessemer Steel slab.
Swedish Rail Section
66 lbs per Yard.
Plan B.
Bessemer Steel.
84 lbs per Yard
Plan C.

which have been already made on those railways. The present experience extends over a period of nine years on portions of the most severely worked lines, namely, at Gottenburg and Malmo; and also during a period of six years on the whole system. The renewals on the main line have been in an increasing proportion, being in one case 30 or 40 per cent. higher than in the preceding year; and a mean calculation gives the probable result that, taking the last renewals of the rails laid down on the lines at about eighteen years from the commencement, the average life of the rails will be fifteen years.

The weight which has passed over the rails during these fifteen years, judging from the reports contained in the annual accounts of the Government Railway Administration, as to the traffic returns of all the State lines, during the years 1862 to 1865, may be assumed to be a yearly increase, in the gross load, of only 15 per cent. per mile, after the year 1865. The yearly increase, however, on the line nearest Gottenburg, since 1862, of transported goods, has amounted to 30 per cent., and near Malmo to 18 per cent. Further, supposing the same proportion to exist between the gross and the nett loads for the year 1865, it may be taken at about 6,000,000 tons, a quantity which, compared with the results obtained on the English lines, giving for the life of the best of the three first sorts of rails, the same average life as that of the **E** rails. This confirms the correctness of the theory that the life of rails is measured by the product of the weight and the speed.

The rails used on the Swedish lines are mostly of the **E** or rolled class before mentioned. Those tried on the Great Northern line were also of that kind of manufacture, but of a heavier section. The speed at which the load was carried over the experimental rails on the Great Northern Railway was much higher than on the Swedish lines, being in the proportion of twenty on the Great Northern to sixteen miles average speed on the Swedish railways..

The conclusions the author has arrived at are, that no rule can be laid down for the manufacture of rails that will apply to every manufacturing district; but, that in the case of Welsh iron, to which he has more particularly referred, it has been proved that the best mode of manufacturing the rails is that now most commonly practiced, viz: rolling the iron into bars, piling these, and repeated rolling to the finished rail, without hammering. The author assumes the prejudicial result from hammering to be owing

to the large amount of sulphur in the Welsh iron. Where the iron contains more phosphorus and less sulphur, as, for instance, in the Cleveland, Belgian, and French iron districts, hammering has proved beneficial, and rails have been made direct from puddled bars, without the intermediate process of piling, this being, in fact, the method generally adopted in those places, and being found to answer best.

These experiments seem to indicate that 220,000,000 tons may be carried over rails, of the section and make referred to, at a speed of one mile per hour; so that any railway company, knowing the load which yearly passes over their line, and the speed, may, by multiplying the one into the other, and dividing that product by 220, ascertain the life of iron rails in years.

(To be continued.)

THE ECONOMICAL CONSTRUCTION OF BEAM TRUSSES.

BY G. S. MORISON, C. E.

(Continued from page 310.)

Trusses continuous through a number of Spans.

IF a single loaded beam rests upon several supports, the load will cause it to bend in a manner similar to that shown in Fig. 31 (Plate II), the curvature being reversed once in each end span, and twice in every intermediate span. The parabolas denoting the bending strains will form a series similar to that shown in the same figure. As the bending strains vanish at the points of reversal, the intermediate part of the beam becomes for the time an independent girder; one-half of its weight is carried in either direction, and the sign of the shearing strains changes midway between these points of reversal, instead of at the centre of the beam, as in isolated spans. But though both classes of strains are affected materially by the condition of continuity, the laws which govern their relative variations do not change; the shearing strains increase uniformly while the load is uniform, and the increment of the chord strains is everywhere the shearing strain divided by the depth of truss. If the negative bending strains over the piers are once known, all other strains are easily determined.

Let A B C D, (Fig. 32, Plate III.), represent a part of a beam distorted by a load, and A b c D the same when relieved of its strains. Unless

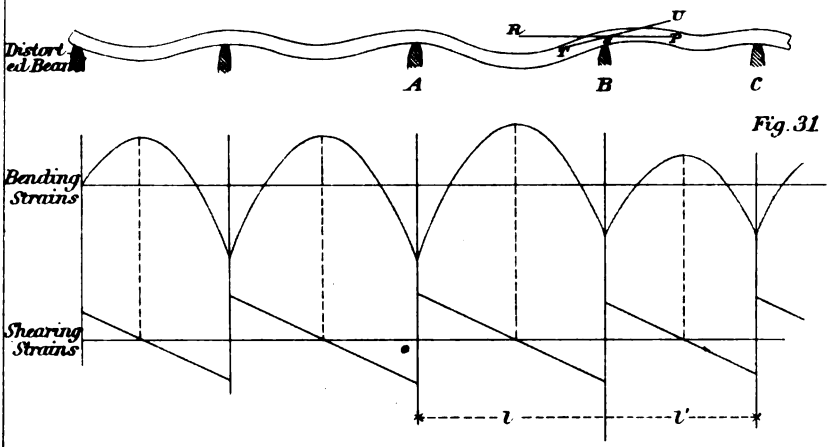


Fig. 31.

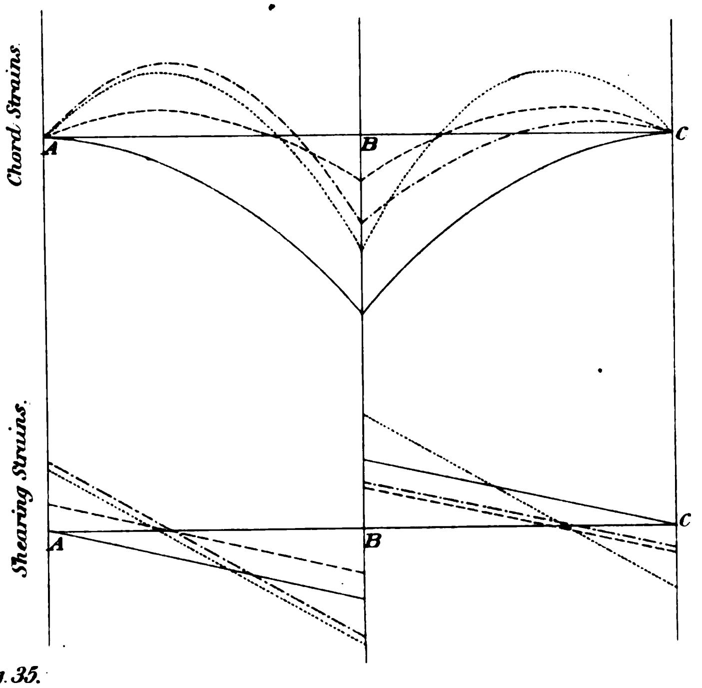


Fig. 35.

Neither Span Loaded. - - - - - - - - - - - - - -

Both Spans Loaded. ....

One Span Loaded. —·—·—·—·—

Bridge Swung. ————————

Lith. Jas McGuigan Philada.

the distortion is excessive, A B may be regarded equal to A E and D F to D c, the elongation of the lower chord being F C, and the shortening of the upper chord, E B. The amount of curvature is given by the angle, G S T = E ob = F o C; the two last angles are respectively proportional to E B and F C, which, being the changes of length caused by the chord strains, are proportional to the sum of the strains acting in A B and D C. It follows that the amount of curvature in a loaded beam is everywhere proportional to the bending or chord strain.

In Fig. 33, Plate III., A B represents one span of a continuous girder. Let S_1 denote the negative chord strain at A and S_2 that at B, A_1 the shearing strain at A and B, that at B, S the chord strain at any point, P, distant x from A. The shearing strain at P will be—

$$A_1 - wx$$

the sum of the shearing strains between A and P

$$A_1\,x - \frac{wx^2}{2}$$

the chord strain at P

$$S = S_1 + \frac{A_1\,x}{h} - \frac{wx^2}{2h} \qquad (1.)$$

and the sum of the chord strain between A and P, given by the negative and positive areas F A M and M X P, or F M X L — A P L F

$$S_1\,x + \frac{A_1\,x^2}{2h} - \frac{wx^3}{6h}$$

Since the amount of curvature is proportional to this sum, angle

$$\text{O T U} = \text{angle O P Q} + \text{angle U R S} = c\left(S_1\,x + \frac{A_1\,x^2}{2h} - \frac{wx^3}{6h}\right) \quad (2.)$$

c being a constant determined by the depth of truss, nature of its material, &c.

Representing by y the elevation or depression of the point P above or below A, tang. angle O P Q becomes the differential co-efficient of y taken relatively to x; as O P Q is exceedingly small, the angle itself may be taken equal to its tangent, and the integral of the last equation gives

$$y - x \times \text{angle U R S} = c\left(\frac{S_1\,x^2}{2} + \frac{A_1\,x^3}{6h} - \frac{wx^4}{24h}\right. \qquad (3.)$$

eliminating A between equations (1) and (3.)

$$y - x \times \text{angle URS} = c\left(\frac{S_1\,x^2}{2} + \frac{S\,x^2}{6} + \frac{wx^4}{24h}\right) \qquad (4.)$$

For the point B, if the two supports are of equal height,

$x = l$, $y = o$, U R S $=$ V X Z, and $S = S^{2}$, and equation (4) becomes—

$$\text{angle V X Z} = c\left(\frac{S_1\,l}{3} + \frac{S_2\,l}{6} + \frac{wl^3}{24h}\right) \qquad (5.)$$

Applying equation (5) to Fig. 30, and denoting the strains over the three supports A B and C by S_1, S_2, and S_3, the lengths A B and B C, by l and l', and their respective loads by w and w', we hence—

$$\text{angle R S T} = c\left(\frac{S_2\,l'}{3} + \frac{S_3\,l'}{6} + \frac{w'\,l'^3}{24h}\right)$$

$$\text{angle P S U} = c\left(\frac{S_2\,l}{3} + \frac{S_1\,l}{6} + \frac{w\,l^3}{24h}\right)$$

But angle P S U $= -$ angle R S T, have—

$$\frac{S_2\,l'}{3} + \frac{S_3\,l'}{6} + \frac{w'\,l'^3}{24h} = -\frac{S_2\,l}{3} - \frac{S_1\,l}{6} + \frac{wl^3}{24h}$$

and reducing—

$$S_1\,l + 2\,S_2\,(l + l') + S_3\,l' + \frac{wl^3}{4h} + \frac{w'\,l'^3}{4h} = 0$$

an equation expressing a single relation between the strains over these successive points of support.

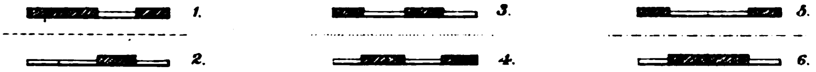
Applying this equation to each set of three successive supports, two less equations are obtained than the entire number of supports. But since the strains over the extreme supports at each end of the girder are equal to zero, the number of equations is the same as the number of unknown quantities.

The shearing strains are determined by equation (1.) which gives, x being made equal to l—

$$A_1 = \frac{(S_2 - S_1)\,h}{l} + \frac{wl}{2}$$

and throughout the span these strains will differ from those in a similar isolated span by the constant quantity, $\frac{(S_2 - S_1)\,h}{l}$. They are more intense at one end than in an isolated spar, and less so at the other, the greater intensity being at that end at which the negative bending strain is the greater.

Having determined the chord strains over the piers, and the shearing strains for the corresponding load, the chord strains at any point may be readily calculated, but will be more readily found by drawing the parabola indicating them. This parabola passes through the points F and G (Fig. 33), A F being equal to S_2 and B G to S_1, and has for its axis the line O H, perpendicular to A B at the point where the shearing strain changes its sign. Since the curvature of this parabola is determined by the inclination of the line, D E, which is de-



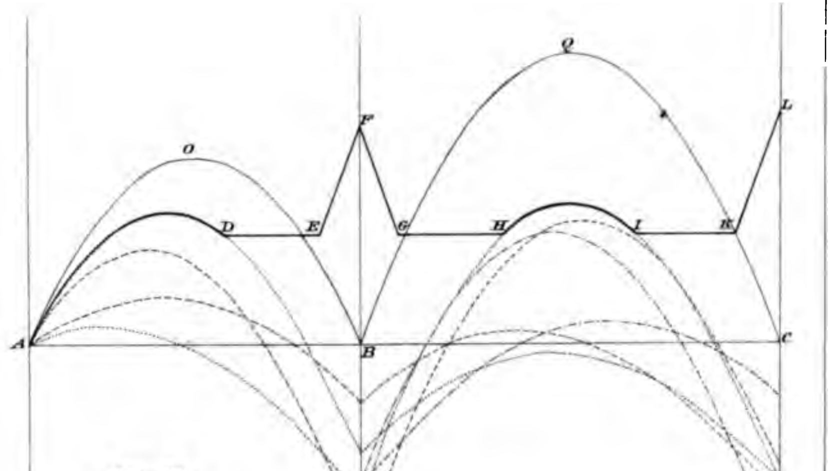
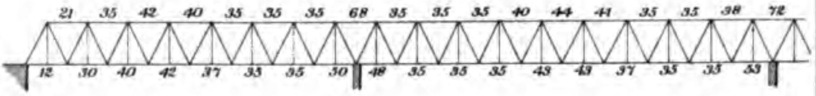


Fig. 36.



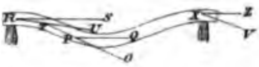
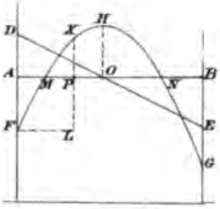


Fig. 34.



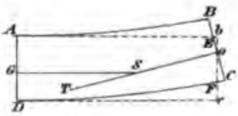


Fig. 32.

[redacted]

pendent solely on the intensity of the load, the parabola will have the same parameter as in a disconnected span, or in a span of different length, but loaded with the same weight per foot.

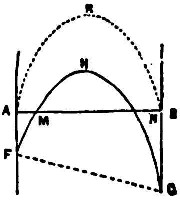
The strains in each span differ materially with the distribution of the load upon the other spans, and it is necessary to consider a number of arrangements of this load, and to proportion the chords at each point with reference to the maximum strain under any possible arrangement. This, though a matter of considerable difficulty when the strains are all calculated, becomes exceedingly simple when they are determined by constructing the corresponding curves.*

It is not necessary to consider all possible distributions of the load, but in general it will be enough to treat each successive span as loaded, and then examine three distributions which make the strains most intense at each end, and at the centre of this span, the last condition occurring when the sum of the strains at both ends of the span is least. When great accuracy is required, the distributions complementary to these should also be examined, though as this will affect the results only near the points of contrary flexure where a considerable excess of metal will always be placed, such an examination is seldom necessary.

Referring to Fig. 34, Plate III., it appears that a weight on either of the spans, a or a^1 increases the strain over A, while weights on b and b^1 by balancing in part the weights on a and a^1, relieves the strain at A_1; and again a load on c and c_1 will relieve the strains at B and B_1,

* The easiest method of drawing these parabolas is to cut a parabola of the desired parameter from a piece of stiff card board, and keeping the axis vertical, move it about till it passes through the points representing S_1 and S_2, then by drawing the pencil along the edge of the card, the desired curve is obtained. The same course should then be repeated for the values of S_1 and S_2, corresponding to a different distribution of the load. If the case of the unloaded span is also considered, two patterns will be needed, one corresponding to the intensity of the dead load, and the other to the moving load alone.

From equations (1) and (6) we obtain for the general equation of the curve of the chord strains (F H G), the origin being transferred to the centre of the span, $S = \frac{S_1(\frac{1}{2}l - x) + S_2(\frac{1}{2}l + x)}{l} + \frac{wl^2 - 2_1x^2}{8h}$, the equation of the corresponding curve (A R B) for an isolated span being $S = \frac{wl^2 - 4x^2}{8h}$ and since $y = S_1\frac{(\frac{1}{2}l - x) + S_2\frac{1}{2}l + x)}{x}$ is the equation of the line F G, the distance of any point in F H G from the line FG_1 is equal to the ordinate of the corresponding point in A R B. This condition furnishes a second simple method of constructing the curves of the chord strain in a continuous girder.



and increase that at A; and in general, the strain over a pier is increased by a weight on the first, third, fifth, &c. span on either side of it, and diminished by a weight on the second, fourth, sixth, &c. The influence of a weight on the spans, *b* and *c* is greater at B than at the more distant support, A, and the sum of the strains at A and B will therefore be increased by weights on $b\ a^1\ d\ c^1$, &c., and diminished by weights on $c\ b^1$, &c.; hence the strain at the centre of a span is diminished by a load on the first, third, fifth, &c., span on either side of it, and increased by a load on the second, fourth, sixth, &c.

As in each end span there is but one point of contrary flexure, the strains in the end spans will be wholly out of proportion to those in the intermediate spans, unless there be a proper difference in their lengths. In a beam fastened at the ends, the distance from each point of reversal to the nearer support has been found to be $\cdot 2113\ l$; in a continuous girder of two equal loaded spans, this distance is $\cdot 25\ l$; and it will be found to average about one-fifth the length of an intermediate, and one-fourth that of an end span. By making the length of the end spans of a continuous truss four-fifths that of the intermediate spans, very nearly the true proportion is obtained, and this simple ratio will be consistent with the use of panels of equal length in every span of a bridge.

The saving of material effected by building a bridge in continuous instead of isolated spans, though obviously great, depends too much upon the special circumstances governing each case, to be expressed by a formula or stated in a table. It is relatively greater in long than in short spans, owing to the increased dead load, greater in a bridge of a large number of spans, than in one of only two or three, while its full advantages will only be obtained when the proper ratio between the lengths of the end and intermediate spans is adopted. An examination of two simple cases will illustrate the use of the formulæ deduced above, and also indicate the economical character of a continuous girder. The first case examined will be that of a pivot draw, the most common example of two connected spans; and the second that of a bridge of four continuous fixed spans.

Case of a Pivot Draw.

The two spans are of equal length; the strains may be examined under four arrangements, including that in which the draw is

swung. When closed, the bridge rests upon three supports, and we have—

$l = l'$ $\quad s_1 = 0 \quad s_3 = 0 \quad$ and equation (6.) becomes—

$$4l\,s^2 + \frac{w_1 l^3}{4h} + \frac{w_2 l^3}{4h} = 0$$

$$s^2 = -\frac{l^2}{16h}(w_1 + w_2)$$

Equation (7.) gives for the shearing strains at the first and third supports—

$$A_1 = \frac{(7\,w_1 - w_2)\,l}{16} \qquad C_2 = -\frac{(7w_2 - w_1)\,l}{16}$$

When the bridge is swung, it becomes a beam resting upon one central support; the shearing strains on either side of this support will be equal to the dead load of one arm of the draw, or $\pm wl$ (w denoting the dead, and w^1 the moving load), decreasing uniformly towards the ends where they vanish. The chord strains are always negative, and vary as the external ordinates of a parabola, from 0 at the ends to $-\frac{wl^2}{2h}$ over the central support. Under the following circumstances, the strains at the support are—

Neither span loaded,	$s_2 = -\frac{l^2}{8h}w$	$A_1 = \frac{3l}{8}w$	$C_2 = -\frac{3l}{8}w$
First " "	$s_2 = -\frac{l^2}{16h}(2w+w^1)$	$A_1 = \frac{l}{16}(6w+7w^1)$	$C_2 = -\frac{l}{16}(6w - w^1)$
Both " "	$s_2 = -\frac{l^2}{8h}(w + w^1)$	$A_1 = \frac{3\,l}{8}(w + w^1)$	$C_2 = -\frac{3l}{8}(w+w^1)$
Bridge swung,	$s_2 = -\frac{l^2}{2h}w$	$A_1 = C_2 = 0$	

The curves indicating the strains through the two entire spans, are shown in Fig. 35 (Plate III.), w being taken equal to $\frac{3}{4}\,w^1$. When $\frac{l^2}{2h}w > \frac{l^2}{8h}(w + w^1)$, or $w > \frac{w^1}{3}$ which will almost always be the case, but two cases need be considered in proportioning the chords that of the open draw, and that of the single loaded span.

It is to be observed, however, that these results are correct only when the draw is fitted with a latch capable of throwing the proper proportion of the dead weight upon the rest piers; otherwise the entire dead weight may always be borne by the centre pier, and the moving load alone should then be distributed in the manner considered above.

(To be continued.)

Mechanics, Physics, and Chemistry.

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Concluded from page 348).

"This first result established, let us recur to the general expression of the pressure corresponding to any point of a liquid surface, an expression which is $P + \frac{A}{2}\left(\frac{1}{R}+\frac{1}{R'}\right)$. For a surface of convex spherical curvature, if we designate by d the diameter of the sphere to which this surface pertains, the above expression becomes $P + \frac{2A}{d}$, and for a spherical surface of concave curvature pertaining to a sphere of the same diameter, we shall have $P - \frac{2A}{d}$. Thus, in the case of the convex surface the total pressure is the sum of two forces acting in the same direction—force, of which one designated by P is the pressure which a plane surface would exert, and the other represented by $\frac{2A}{d}$ is the action which depends on the curvature. On the contrary, in the case of the concave surface the total pressure is the difference between two forces acting in opposite directions, and which are again, one the action P of a plane surface, and the other $\frac{2A}{d}$, which depends on the curvature. Whence it is seen that the quantity $\frac{4A}{d}$, which represents the pressure exerted by a spherical film on the air it encloses, is equal to double the action which proceeds from the curvature of one or the other surface of the film.

"Now, when a liquid rises in a capillary tube, and the diameter of this is sufficiently small, we know that the surface which terminates the column raised does not differ sensibly from a concave hemisphere, whose diameter is consequently equal to that of the tube. Let us recall, moreover, a part of the reasoning by which we arrive, in the theory of capillary action, at the law which connects the

height of the column raised with the diameter of the tube. Let us suppose a pipe, excessively slender, proceeding from the lowest point of the hemispheric surface in question, descending vertically to the lower orifice of the tube, then bending horizontally, and finally rising again so as to terminate vertically at a point of the plane surface of the liquid exterior to the tube. The pressures corresponding to the two orifices of this little pipe will be, on the one part, P, and on the other, $P - \frac{2A}{\delta}$, if by δ be designated the diameter of the concave hemisphere, or, what amounts to the same thing, that of the tube. Now, the two forces P, mutually destroying one another, there remains only the force $-\frac{2A}{\delta}$, which, having a sign contrary to that of P, acts consequently from below upwards at the lower point of the concave hemisphere, and it is this which sustains the weight of the molecular thread contained in the first branch of the little pipe between the point just mentioned and a point situated at the height of the exterior level. This premised, let us remark that the quantity $\frac{2A}{\delta}$ is the action which results from the curvature of the concave surface. The double of this quantity or $\frac{4A}{\delta}$, will therefore express the pressure exerted on the enclosed air by a laminar sphere or hollow bubble of the diameter δ, and formed of the same liquid. It thence results that this pressure constitutes a force capable of sustaining the liquid at a height double that to which it rises in the capillary tube, and that, consequently, it would form an equilibrium to the pressure of a column of the same liquid having that double height. Let us suppose, for the sake of precision, δ equal to a millimètre, and designate by h the height at which the liquid stops in a tube of that diameter. We shall have this new result, that the pressure exerted on the enclosed air by a hollow bubble formed of a given liquid and having a diameter of 1 millimètre, would form an equilibrium to that exerted by a column of this liquid of a height equal to $2h$. Now, the pressure exerted by a bubble being in inverse ratio to the diameter thereof, it follows that the liquid column which would form an equilibrium to the pressure exerted by a bubble of any diameter whatever, d, will have a height equal to $\frac{2h}{d}$.

"It would seem, at first, that this last expression ought to apply equally well to liquids which sink in capillary tubes, h then designating this subsidence, the tube still being supposed 1 millimètre in diameter; but is not altogether so, for that would require, as is readily seen by the reasonings which precede, that the surface which terminates the depressed column in the capillary tube should be sensibly a convex hemisphere; now we know that in the case of mercury this surface is less curved; according to the observations of M. Bède, its height is but about half of the radius of the tube; whence it follows that the valuation of the pressure yielded by our formula would be too small in regard to such liquids. It may be considered, however, as a first approximation.

Let us take, as a measure of the pressure exerted by a bubble, the height of the column of water to which it would form an equilibrium. Then, if δ designates the density of the liquid of which the bubble is formed, that of water being 1, the heights of the columns of water and of the liquid in question which would form an equilibrium to the same pressure will be to one another, in the inverse ratio of the densities, and, therefore, if the height of the second is $\frac{2h}{d}$, that of the first will be $\frac{2h\delta}{d}$. Hence, designating by p the pressure exerted by a laminar sphere on the air which it encloses, we obtain definitely $p=\frac{2h\delta}{d}$, δ being, as we have seen, the density of the liquid which constitutes the film, h the height to which this liquid rises in a capillary tube 1 millimètre in diameter, and d the diameter of the bubble. If, for example, the bubble be formed of pure water, we have $\delta=1$, and, according to the measurements taken by physicists, we have, very exactly, $h=30^{mm}$; the above formula, therefore, will give, in this case, $p=\frac{60}{d}$. If we could form a bubble of pure water of one decimetre or 100^{mm}, in diameter, the pressure which it would exert would consequently be equal to $0^{mm}{\cdot}6$, or, in other terms, would form an equilibrium to the pressure of a column of water $0^{mm}{\cdot}6$ in height; the pressure exerted by a bubble of the same liquid one centimetre, or 10^{mm} in diameter, would form an equilibrium to that of a column of water 6^{mm}. As regards soap-bubbles, their pressures, if the solution were as weak as possible, would differ very little from

those exerted by bubbles of the same diameters formed of pure water.

"For mercury we have $\delta = 13{\cdot}59$, and, according to M. Bède, h about equal to 10^{mm}; the formula would therefore give, for a bubble of mercury $p = \frac{271{\cdot}8}{d}$, but, from the remark which closes the last paragraph, this value is too weak, and can only be regarded as a first approximation. It only instructs us that, with an equality of diameter, the pressure of a bubble of mercury would exceed four and a half times that of a bubble of pure water. For sulphuric ether, we have $\delta = 0{\cdot}715$, and conclude from measurements taken from M. Frankenheim, h to be very closely to $10^{mm}{\cdot}2$; whence results $p = \frac{14{\cdot}6}{d}$, and thus, with an equal diameter, the pressure of a bubble of sulphuric ether would be but the fourth of that of a bubble of pure water.

We know that the product $h\delta$ being the product of the capillary. height by the density, is proportional to the molecular attraction of the liquid for itself, or, in other terms, to the cohesion of the liquid; (see research of Prof. Henry on Cohesion of Liquids, quoted in §V.) it is, moreover, the result from a comparison of the values $\frac{4\,\mathrm{A}}{d}$ and $\frac{2\,h\delta}{d}$, which have been found to represent the pressure exerted by a lan inar sphere on the air which it contains; hence we deduce $h\delta = 2\,\mathrm{A}$, and it will be remembered that A is the capillary constant; that is to say, a quantity proportional to the cohesion of the liquid. The formula $p = \frac{2\,h\delta}{d}$ indicates, therefore, as must be evident, that the pressure exerted by a laminary bubble on the included air is in the direct ratio of the cohesion of the liquid which constitutes the film and the inverse ratio of the diameter of the bubble.

"As early as 1830, a learned American, Dr. Hough, had sought to arrive at the measure of pressure exerted, whether on a bubble of air contained in an indefinite liquid or on the air enclosed in a bubble of soap.

(*Inquiries into the principles of liquid attraction.*—Silliman's Journal, 1st series, vol. xvii., page 86.)

"He conceives quite a just idea of the cause of these pressures which he does not, however, distinguish from one another, and, in

order to appreciate them, sets out, as I have done, with a consideration of the concave surface which terminates a column of the same liquid raised in a capillary tube; but, although an ingenious observer, he was deficient in a knowledge of the theory of capillary action, and hence arrives, by reasoning, of which the error is palpable, at values and a law which are necessarily false.

"Prof. Henry, in a very remarkable verbal communication on the cohesion of liquids, made in 1844, to the American Philosophical Society, (Philosophical Magazine, 1845, vol. xxvi., page 541), described experiments by means of which he had sought to measure the pressure exerted on the internal air by a bubble of soap of a given diameter. According to the account rendered of this communication, the mode of operation adopted by Mr. Henry was essentially as follows: he availed himself of a glass tube of **U** form, of small interior diameter, one of whose branches was bell-shaped at its extremity, and inflated a soap-bubble extending to the edge of this widened portion; he then introduced into the tube a certain quantity of water, and the difference of level in the two branches gave him the measure of the pressure. Unfortunately, the statement given does not make known the numbers obtained, nor does it appear that Mr. Henry has subsequently published them. This physicist refers the phenomenon to its real cause, and states the law which connects the pressure with the diameter of the bubble; the account does not say whether the experiments verified it. But Mr. Henry considers that a hollow bubble may be assimilated to a full sphere reduced to its compressing surface; that is to say, he attributes the phenomenon to the action of the exterior surface of the bubble, without taking into account that of the interior surface. Let us add that, in the same communication, Mr. Henry has mentioned several experiments which he had made on the films of soap and water, and which, from the statement given would elucidate, in a remarkable manner, the principles of the theory of capillary action. It is much to be regretted that these experiments are not described

"In a memoir presented to the Philomatic Society in 1856, and printed in 1859 in the *Comptes Rendus*, (tome xlviii., page 1405.) M. de Tessan maintains that if the vapor which forms clouds and fogs were composed of vesicles, the air enclosed in a vesicle of 0·02 millimètre diameter would be subjected, on the part of this vesicle, to a pressure equivalent to $\frac{1}{7}$ of an atmosphere. M. de Tessan does

not say in what manner he obtained this valuation; but it is easily seen that he has fallen into an error analogous to that of Professor Henry, in the sense that he pays no attention except to the exterior surface of the liquid pellicle. According to the formula of the preceding paragraph, the pressure exerted on the interior air by a bubble of water of 0·02 millimètre diameter would, in fact, be equivalent to that of a column of water 3 metres in height, which equals nearly $\frac{2}{7}$ of the atmospheric pressure; M. de Tessan has found then but half the real value, and we know that this half is the action due to the curvature of one only of the surfaces of the film.

"After having obtained the general expression of the pressure exerted by a laminar sphere on the air which it encloses, it remained for me to submit my formula to the control of experiment. I have employed, with that view, the process of Mr. Henry, which means that the pressure was directly measured by the height of the column of water to which it formed an equilibrium.

From our formula we deduce $p\,d = 2\,h\,\delta$; for the same liquid, and at the same temperature, the product of the pressure by the diameter of the bubble must, therefore, be constant, since h and δ are so. It is this constancy which I have first sought to verify for bubbles of glyceric liquid—(a solution of Marseilles soap and glycerine in distilled water, with which Plateau made his bubbles)—of different diameters."

Plateau here describes his apparatus and the precautions to be used in making the measures, which the reader will find detailed in the Smithsonian Report for 1865.

"The following table contains the results of these experiments; I have arranged them, not in the order in which they were obtained, but in the ascending order of the diameters, and I have distributed them into groups of analogous diameters. During the continuance of the operations the temperature varied from 18°·5 to 20° C.

* * * * As the first diameter is to those of the last group very nearly as 1 to 6, these results suffice, I think, to establish distinctly the constancy of the product $p\,d$, and consequently the law according to which the pressure is in the inverse ratio of the diameter.

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"As to the general mean 22·75 of the results of the table, its decimal part is necessarily a little too high, on account of the excessive value 26·45 of the last product. As this product, and that which

precedes it, are those which alone deviate materially from 22 in this integral part, it will be admitted, I think, that a nearer approach to the true value will be made by neglecting these two products and taking the mean of the others, a mean which is 22·56, or more simply 22·6; we shall adopt, then, this last number for the value of the product $p\,d$ in regard to the glyceric liquid.

Diameters, or values of d.	Pressures, or values of p.	Products, or values of $p\,d$.
mm	mm	
7·55	3·00	22·65
10·37	2·17	22·50
10·55	2·13	22·47
23·35	0·98	22·88
26·44	0·83	21·94
27·58	0·83	22·89
46·60	0·48	22·37
47·47	0·48	22·78
47·85	0·43	20·57
48·10	0·55	26·45

It remained to be verified whether this value satisfied our formula, according to which we have $p\,d = 2\,h\,\delta$, the quantities δ and h being respectively, as we have seen, the density of the liquid and the height which this liquid would attain in a capillary tube 1 millimètre in diameter. With this view, therefore, it was necessary to seek the values of these two quantities in reference to the glyceric liquid. The density was determined by means of the aerometer of Fahrenheit, at the temperature of 17° C., a temperature little inferior to that of the preceding experiments, and the result was $\delta = 1{\cdot}1065$. To determine the capillary height the process of Gay Lussac was employed, that is, the measurement by the cathetometer, all known precautions being taken to secure an exact result. The experiment was made at the temperature of 19° C. * * * * * * * The reading of the cathetometer gave, for the distance from the lowest point of the concave meniscus to the exterior level, $27^{mm}{\cdot}35$.

This measurement having been taken, the tube was removed, cut at the point reached by the capillary column, and its interior diameter at that point measured by means of a microscope, furnished

with a micrometer, giving directly hundredths of a millimètre. It was found that the interior section of the tube was slightly elliptical, the greater diameter being $0^{mm}\cdot374$ and the smaller $0^{mm}\cdot357$; the mean was adopted, namely, $0^{mm}\cdot3655$, to represent the interior diameter of the tube assumed to be cylindrical. To have the true height of the capillary column, it is necessary, we know, to add to the height of the lowest point of the meniscus the sixth part of the diameter of the tube, or, in the present case, $0^{mm}\cdot06$; the true height of our column is consequently $27^{mm}\cdot41$. Now, to obtain the height h to which the same liquid would rise in a tube having an interior diameter of exactly a millimètre, it is sufficient, in virtue of the known law, to multiply the above height by the diameter of the tube, and thus we find definitively $h = 10^{mm}\cdot018$.

"I should here say for what reason I have chosen for the experiment a tube whose interior diameter is considerably less than a millimètre. The reasoning by which I arrived at the formula supposes that the surface which terminates the capillary column is hemispherical; now that is not strictly true, but in a tube so narrow as that which I have employed, the difference is wholly inapplicable, so that in afterwards calculating, by the law of the inverse ratio of the elevation to the diameter, the height for a tube one millimètre in diameter, we would have this height such as it would be if the upper surface were exactly hemispherical.

"The values of δ and h being thus determined, we deduce therefrom $2\,h\,\delta = 22\cdot17$, a number which differs but little from $22\cdot56$ obtained above as the value of the product $p\,d$. The formula $p\,d = 2\,h\,\delta$ may therefore be regarded as verified by experiment, and the verification will appear still more complete if we consider that the two results are respectively deduced from elements altogether different. I hope hereafter to obtain new verifications with other liquids.

Investigation of a very small limit below which is found, in the glyceric liquid, the value of the radius of sensible activity of the molecular attraction.

"The exactness of the formula $p = \frac{2\,h\,\delta}{d}$ supposes, as we are about to show, that the film which constitutes the bubble has, at all points, no thickness less than double the radius of sensible activity of the molecular attraction.

"We have seen that the pressure exerted by a bubble on the air which it encloses is the sum of the actions separately due to the curvatures of its two faces. On the other hand, we know that, in the case of a full liquid mass, the capillary pressure exerted by the liquid on itself emanates from all points of a superficial stratum having as its thickness the radius of activity in question. Now, if the thickness of the film which constitutes a bubble is everywhere superior or equal to double that radius, each of the two faces of the film will have its superficial stratum unimpaired, and the pressure exerted on the enclosed air will have the value indicated by our formula. But if, at all its points, the film has a thickness inferior to or double this radius, the two superficial strata have not their complete thickness, and the number of molecules comprised in each of them being thus lessened, these two strata must necessarily exert actions less strong, and consequently the sum of these, that is to say, the pressure on the interior air, must be smaller than the formula indicates it to be. Hence it follows that if, in the experiments described above, the thickness of the films which formed the bubbles had, through the whole extent of these last, descended below the limit in question, the results would have been too small, but in this case we should have remarked progressive and continued diminutions in the pressures, which, however, never happened, although the color of the bubbles evinced great tenuity. But all physicists admit that the radius of sensible activity of the molecular attraction is excessively minute.

"But what precedes permits of our going further, and deducing from experiment a datum on the value of the radius of sensible activity, at least in the glyceric liquid. * * *

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"After the film has acquired a uniform thinness, if the pressure exerted on the air within the bubble underwent a diminution, this would be evinced by the manometer, and it would be seen to progress in a continuous manner in proportion to the ulterior attenuation of the film. In this case the thickness which the film had when the diminution of pressure commenced would be determined by the tinge which the central space presented at that moment, and the half of that thickness would be the value of the radius of sensible activity of the molecular attraction. If, on the contrary, the pressure remains constant until the disappearance of the bubble, we may infer from the tint of the central space the final thickness of the film, and

the half of this thickness will constitute at least a limit, very little below which is to be found the radius in question.

* * * * * * * *

* * * I deposited in the bottom of the dry jar, morsels of caustic potash, and contrived by the application of a little lard around the orifice of the jar and of the aperture through which passed the copper tube, that after the introduction of the bubble, the pasteboard disk should close the opening hermetically. * *

* * * * * * * *

"Now, under these conditions, the diminution of thickness of the film was continuous, the bubble lasted for nearly three days, and when it burst, it had arrived at the transition from the yellow to the white of the first order; it then presented a central space of a pale yellow tint, surrounded by a white ring.

* * * * * * * *

* * * if the pressure varied, it was in an irregular manner, in both directions, and terminating not in a diminution, but an augmentation, at least relative; we may, therefore, admit, I think, that the final thickness of the film was still superior to double the radius of sensible activity of the molecular attraction.

"Let us now see what we may deduce from this last experiment. According to the table given by Newton, the thickness of a film of pure water which reflects the yellow of the first order is, in millionths of an English inch, $5\frac{1}{3}$, or 5·333, and for the white of the same order $3\frac{7}{8}$, or 3·875. We may therefore take the mean, namely 4·064, as the closely approximative value of the thickness corresponding, at least in the case of pure water, to the transition between those colors, and the English inch being equal to 25·4 millimètres, this thickness is equivalent to $\frac{1}{9684}$ of a millimètre. Now we know that, for two different substances, the thickness of the films which reflect the same tint is in the inverse ratio of the indices of refraction of those substances. In order, therefore, to obtain the real thickness of our film of glyceric liquid, it suffices to multiply the denominator of the preceding fraction by the ratio of the index of the glyceric liquid to that of water. I have measured the former approximatively by means of a hollow prism, and have found it equal to 1·377. That of water being 1·336, there results, for the thickness of the glyceric film $\frac{1}{9981}$ of a millimètre. The half of this quantity, or $\frac{1}{19962}$ of a millimètre, constitutes, therefore, the limit furnished by the experiment in question. Hence we arrive at the

very probable conclusion, that in the glyceric liquid the radius of sensible activity of the molecular attraction is less than $\frac{1}{17000}$ of a millimètre.

"I had proposed to continue this investigation with a view to reach, if possible, the black tint, and to elucidate the variations of the manometer; but the cold season has intervened, diminishing the persistence of the bubbles, and I have been forced to postpone attempts to a more favorable period."

In the report of the transactions of the Society of Physics and Natural History, of Geneva, 1862, we find the following: "Prof. Wartmann, Jr., repeated before the Society the recent experiments of M. Plateau on bubbles of soap, of varied forms as well as much persistency, obtained by mixing with soap-suds a small quantity of glycerine, and causing the bubbles to attach themselves to iron wires arranged in different manners. At a subsequent session M. Wartmann exhibited an apparatus of the same kind, still more varied, so as to produce more perfectly than by former processes the phenomena of coloration in extremely thin surfaces of the liquid. The dark part presents not more than $\frac{1}{104920}$ of a millimètre, whence we may conclude, says M. Wartmann, that the radius of the sensible activity of molecular attraction is below $\frac{1}{209000}$ of a millimètre."

CAN WE RAISE OUR OWN SUGAR?*

BY H. W. BARTOL, ESQ.

CAN we raise our own sugar? This question having often been asked me, and various articles having appeared in the papers on beet sugar, I have thought that a few words as to how it is made in Europe, and the probable success it would meet with in this country might not be uninteresting to the community at large.

Cane sugar was first discovered in the beet, in the year 1747, by a German chemist, named Margraf; and, in 1796, M. Achard analyzed the beet, and obtained 5 per cent. of white sugar; but it was not until the rule of Napoleon I., who offered a prize of $200,000 for the best method of producing sugar from native productions, that beet-root sugar-making reached any importance.

The discovery thus made and put into practical operation, was

* In all places where I speak of France, the money referred to is gold; but wherever this country is referred to greenbacks are understood to be the standard.

nursed by enormous protective duties, which, at one time, raised the price of sugar as high as $1.25 per pound.

Under this state of affairs, sugar-making became an important branch of industry, and many improvements were made by which the yield of sugar, which at first was only 3 per cent., was augmented to 5; this was the state of affairs at the time of the restoration, when the duties being removed, sugar-making from beets, in France, became a thing of the past.

Beet-root sugar-making remained dormant, as it were, for some time: but a great industry can no more be crushed than a great truth, and Napoleon III. seeing this, commenced a judicious course of protection, which has brought beet-root sugar-making to its present state of perfection.

Science having increased the yield of sugar from 3 to 8 per cent., (and in some factories as high as 9 and 10 per cent.,) and improved machinery diminishing the cost of production, so that to-day beet sugar not only stands on a par with that made from cane, but actually drives it out of the European market, many refiners in England (where all foreign sugar enters on the same terms,) using it entirely, and preferring it to that made from cane, it being much clearer.

Can beet sugar be made in this country? Let us look into the matter, and decide for ourselves.

The best white sugar (equal to Lovering's A,) is sold in France at 11·5 cents per pound, from which we must deduct the Government tax of 4·09 cents, leaving the manufacturer 6·41 cents per pound to pay all his expenses and make his profit from.

If the French manufacturer can sell his sugar at that price, surely we can make it at double the price, and sell it at 16 cents, leaving a clear profit of 3·16 cents per pound; and in a factory working sixty tons of beets in twenty-four hours, (the smallest size factory it is profitable to run,) yielding 7 per cent. of sugar, we would have a profit of $265.44 per day.

In order that you may the better understand the terms I may hereafter use, I will give a short description of how beet sugar is made.

The beets being brought to the factory, are thrown into a large, revolving cylinder, set on an angle, and immersed one-half in running water, in which, by means of cams, they are gradually worked to the upper end and thrown out clean on to a revolving table, around which stand a number of women, who take off the beets

and cut out the bad parts, after which the beets are conveyed to the rasp.

This machine is a drum, encased in a cylinder, in which it revolves; the circumference of the drum is composed of a series of saw plates, set in it radially, with the teeth out, so as to form a number of sharp points; this drum revolves with great rapidity, so that the beets, which are introduced at the top with 30 per cent. of water, are immediately grated, and pass out at the bottom in the form of fine pulp.

And now comes the point of dispute. There are three ways of extracting the juice from the pulp, viz: 1. Hydraulic Presses; 2. Centrifugals; 3. Macerators..

For brevity's sake, I will merely mention the first two, the last being very little used.

In the press process, the pulp is put in bags, and subjected to a great pressure in hydraulic presses, which expresses the juice, and leaves a dry mass.* Where fuel and water are scarce, it is imperative to use this process, as it requires less of both than any other way, and, in fact, is the most generally used.

By the centrifugal process, the pulp is placed in vertical wire cylinders, about 3 feet in diameter, 18 inches high, revolving with a velocity of 1200 revolutions per minute, which, by its centrifugal action, drives the pulp with great force against the wire sides, and they being too finely woven to allow the pulp to pass through, retain it, and let the juice flow off, when it is caught by an exterior cylinder, and conveyed by canals to its proper receptacle.

This process has the advantage of requiring 50 per cent. less manual labor than the presses, but requires a large amount of additional water, (40 per cent.) which is used in washing the juice out of the pulp; while in the centrifugal machine, which water, in its turn, thins the juice, so that it requires more fuel to evaporate it.

There is another process coming into vogue, in Germany, called the "Roberts' Diffusing Process," but, as it is a new thing, and not fully proved, I refrain from speaking of it.

The juice, obtained by any of these processes, is taken to what is called a decarbonizer, which is really nothing but an iron tank, fitted with two sets of pipes, one for steam and the other for carbonic acid gas.

* The dry pulp is sold to feed cattle, at the same price that is paid for the beets.

In this vessel the juice is heated to 180°, and milk of lime added until the liquor is strongly alkaline; it is then neutralized by forcing in carbonic acid gas, which, uniting with the lime, forms a a precipitate, which, in settling, carries down with it many of the impurities held in suspension.

The juice is allowed to settle, when the clear portions, of a light straw color, is drawn off, while the settlings are passed through filter-presses, which extract the clear juice, and leave a dry mass, composed principally of carbonate of lime.

The process, from this out, is the same as that pursued with cane sugar. The juice is boiled down to the required density, (27° Beaumé,) passed over animal black, re-boiled to grain, and put into small tanks where, after remaining a few days to crystalize, it is passed through centrifugal machines, in the ordinary way, and comes out dry sugar.

But why should it cost us twice as much as the French to make sugar, as the necessary articles to make it are certainly not twice as dear in this country, with the one exception of labor; and if it can be shown that labor makes not quite one-third of the expense on a pound of beet sugar, and that we can and have raised beets in this country as cheaply as in France*, it seems to me that all doubt on the subject is removed; to prove this, I refer to the following tables.

The following is the table of the working of a French house, and all the figures used in it are strictly correct. The profit named is very low, in order to make the working expenses as heavy as possible. The 10 per cent. loss in the beets is the bad parts, which are cut out, as before mentioned.

EXPENSES.

60 tons of beets, at $3.75	$225 00
Running expenses	273 90
Gov't tax at 4·09 cents per lb. in 8,400 lbs. sugar	353 86
Total	$852 76

* Mr. Gennert, Superintendent of the Germania Beet Sugar Company, of Chattsworth, Illinois, assures me that his average yield per acre, in fair years, is fifteen tons of beets, containing 12 per cent of saccharine matter, and that the cost of raising them, everything included, is not quite $3.00 per ton. In France, the tax being on the sugar, they average eighteen tons, containing from 10 to 12 per cent.; while in Germany, where the tax is on the beets, they endeavor to get the most sugar in the fewest beets, and, consequently, do not average more than fifteen tons, containing from 12 to 15 per cent. of sugar.

RECEIPTS.

7 per cent. of sugar on 60 tons beets less 10 p. ct. loss, 8,400 lbs. sugar at $.103	$865 20
15 per cent. pulp, = 9 tons at $3.75	32 44
Total	$897 64
Less expenses	852 76
Profit per day	$44 88

In this calculation, I have left out a small amount of syrup, as the probabilities are that it would be impossible to sell it in this country, on account ef its extremely unpleasant taste. In France, it is made into alcohol.

Having now arrived at the cost of manufacture in France, let us see how we would come out in America, where the cost of labor is about twice as great. (In France a man receives sixty cents, gold, per day; in this country, a man for the same work can be hired for about double that amount, in greenbacks.* It must be remembered that these are country wages, and always lower than city prices.)

In the following tables, I have put the beets at $2.00 per ton† higher than Mr. Gennert makes them, as my object is not so much to show the exact amount of profit to be derived in this country as to establish, beyond a doubt, that we *can raise our own sugar.*

Factory working 60 tons of beets per day in America:

EXPENSES IN GREENBACKS.

60 tons of beets, at $5.00	$300 00
Expenses of running double those in France	547 80
Total	$847 80

RECEIPTS.

Sugar, 7 p. ct. on 60 tons, less 10 p. c. =8,400 lbs., at 15 cts	$1,260 00
15 per cent. pulp, $5 per ton	45 00
Total	$1,305 00
Less expenses	847 80
Profits per day	$457 20

* See Report of Commission of Agriculture for June, 1866.

† From all the data I can collect, beets can be raised as cheaply as corn, and the Commissioner of Agriculture, in his report for June, 1866, gives as the average crop of corn, in twenty-two States of the Union, from the year 1862 to 1865, inclusive, as 32 99 bushels per acre,

Which, at $1.00 per bushel, (a very high price,) would be	$32 99
While 15 tons of beets, at $5.00 per ton, would give	75 00
Balance in favor of beet grower	$48 01

As to the richness of our beets in sugar, I refer to the following analysis made by me:

	DATE.	PER CENT. OF SUGAR.
Beets grown at Ellwood, New Jersey........	Nov. 3, 1867.	12
" " " "	" 7, 1867.	12
" near Boston, Mass..........	" 15, 1867.	11·40
" by Germania Sugar Co..........	Jan. 15, 1868.	12·00

Most of these beets were grown by persons having no knowledge of raising them for sugar making.

Few people are aware of the great extent to which beet-root sugar is made in Europe, I therefore give the following table, extracted from the *Journal des Fabricants des Sucre*, giving the amount of sugar made in Europe during the season of 1867 and 1868. (The sugar-making season commences October 1st, and ends April 1st.)

	Tons.
Associated Germany..........	165,000
France..........	220,000
Russia..........	97,500
Belgium..........	82,500
Poland and Sweden..........	15,000
Holland..........	7,500
Austria..........	92,500
Total..........	680,000

If, then, Europe can raise her own sugar, why cannot we, and keep at home, to enrich our own land, the $80,000,000 of gold we annually send to foreign countries for that article?

If necessary, let the Government imitate Napoleon I. by offering large prizes for the first successful establishment, so that, if, in the future, the much-vexed question is asked, "Can We Raise Our Own Sugar?" we may respond with pride, "We can, and do!"

H. W. BARTOL.

INVERTED SYPHONS IN THE SEINE.

SINCE the middle of last month, the works belonging to the new drainage scheme have advanced to such a pitch that to complete them it was necessary to get the syphons sunk, which acted as the general collector of the storm and other waters draining from the left bank of the Seine. The syphons themselves, consisting of wrought iron cylindrical tubes, are first rendered completely water-tight and then immersed in the river, where they float half in and half out of the water. To accomplish this operation successfully, a certain amount of current is required, as well at a certain depth of Water, in order to bring them right over that portion of the bed of the river which will constitute their ultimate site. The first tube having been hauled perpendicularly over the proper spot, was uncorked, if we may use the term, and, after gradually filling, descended quietly into its place without the slightest mishap of any kind. The success which attended the sinking of the first syphon was hailed as a good omen for that impending over its neighbor, but unfortunately some time elapsed before the omen was fulfilled. Upon the day fixed for its immersion, the velocity of the river had increased, and the level of its surface had fallen 6½ feet. The cause was the bursting of the dam of Grande-Jatte, at Neuilly, which, together with the increase of the velocity of the current, put an end to the preparations for sinking the second tube. It was accordingly towed to a place of safety, and made fast. As it was impossible to repair the breach made in the dam at Neuilly, and as the navigation was seriously interfered with by the sudden lowering of the water. recourse was had to the weir at the bridge of Jena, which was purposely adapted for such contingencies. By its means a sufficient head of water was obtained, and the operation of placing the second tube alongside its predecessor proceeded with. The cylinders, of wrought iron, with countersunk rivets, were constructed at the establishment of Chaillot, and their total length from wall to wall of the river is about 450 feet. After being sunk, they will be encased in an envelope of bêton, 16 inches thick, to protect them from the heaving of anchors, the action of dredging, or any other cause that might be likely to damage them. There does not seem to be any cogent reason why the cheaper material, cast iron, should not have been employed in lieu of wrought in the construction of these tubes. They have no weight to sustain, no real work to do. We should have regarded an instance of this kind as one peculiarly adapted for the employment of cast iron, but judging from this case and that of the late exposition, that material is manifestly not a favorite with continental engineers.—*Mechanics' Magazine.*

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

BY PROF. HENRY MORTON, PH.D.

(Continued from page 351.)

WE propose here to place a section which might be considered as a long note, since it contains matter not developed in the lecture, but which may, perhaps, be introduced, with propriety, in this connection, as involving that which is worth putting on record at this time, while the events are fresh in memory, and authorities in the subject personally accessible for correction or emendation. We propose, in fact, to give a brief sketch of Celestial Photography, which may place the succession of the laborers in this field in true order, and afford a guide to the literature of the subject.

The first photograph of a celestial object was taken by Dr. J. W. Draper, of New York, in 1840. This was followed by Prof. G. P. Bond, of Cambridge, U. S., who, in 1850, made a picture of the moon on a daguerreotype-plate, in the great Cambridge refractor of 15-inch aperture.

During the years which succeeded, there appeared in the field of Celestial Photography, Father Secchi, in Rome, Birch and Arnaud, in France, and Phillips, Hartnup, Crookes, De la Rue, Fry, Dancer, Huggins, Williamson and Baxendell. The first detailed description of experiments was published by Professor Phillips, who read a paper on this subject before the British Association in 1853. Professor Phillips made his pictures with a 6¼-inch refractor by Cooke, of 11 feet focus, which produced negatives of the moon 1¼ inches in diameter, in 30 seconds. A paper was next communicated to the Royal Society, by Crookes, in December of 1856; he subsequently obtained dense negatives in 4 seconds. In May, 1857, Mr. Grubb read a paper on this subject before the Dublin Photographic Society.

In 1859, De la Rue read a paper before the British Association. His experiments were commenced in 1852, with a reflecting telescope of his own manufacture.

In 1860, De la Rue and his assistants made several excellent negatives of the solar eclipse; and he was much interested in the establishment of the Photoheliograph at Kew, with which pictures of the sun, showing the "spots" and their changes, have been made almost daily since.

In the *Quarterly Journal of Science*, for April, 1864, appeared a paper by Professor Henry Draper, M. D., in which he describes the progress of his experiments in constructing a reflecting telescope of glass, silvered on the first surface, by Foucault's plan, designed especially for the purposes of Celestial Photography. After grinding and polishing more than one hundred experimental mirrors, the art was at last fully acquired, and the work is now, as Dr. Draper has informed us, a certain and not very lengthy process.

The mirror, which was finally mounted, was of 15½ inches diameter and 12½ feet focal length, and with this 1,500 negatives have been taken, of which very many are of great excellence. We have now before us a print, on paper, from one of these negatives, showing the moon in the third quarter, with a diameter of 30 inches, and we have seen one reaching the enormous size of *five feet.*

In *Silliman's Journal*, for May, 1865, Mr. Louis M. Rutherfurd gives an account of his labors in this field, in the first place with a refractor and a silvered glass reflector of the usual construction, and then with a refractor made by himself, and corrected only for the chemical rays. This instrument was completed in December, 1864, but it was only in March, 1865, that the atmospheric conditions were sufficiently favorable to admit of a trial.

We have before us a set of four pictures, bearing date respectively, March 4th, 6th, 8th and 10th, which are the work of this instrument, and about which (mistrusting our own judgment where a fellow-countryman is concerned,) we will quote the expression given by Mr. Brothers, an eminent English laborer in the same field, who, in a chapter written for Mr. G. F. Chambers' admirable Astronomy, just published, says,*—"To an American (Mr. Rutherfurd,) we are indebted for the best photograph of our satellite yet produced, and, indeed, it is difficult to conceive that anything superior can ever be obtained.

(To be continued.)

* To this chapter by Mr. Brothers, we owe most of the matter given above, endorsed, however, by a direct communication with Mr. Rutherfurd and Dr. Draper.

LECTURES ON VENTILATION.

By Lewis W. Leeds.

Second Course, delivered before the Franklin Institute, during the winter of 1867–68.

(Continued from page 355.)

LECTURE II.

The air we breathe—what is it? Oxygen and nitrogen, the young student will promptly answer. Oxygen and nitrogen certainly; but how many of us really comprehend what these elements are?

We are told that the distance around the earth is *so* many thousand miles, and so many more to the sun, and that the nearest fixed star is a great many millions of miles from us; but it is no matter how many (though the astronomers have stated it all with accuracy), because I believe it is entirely impossible for the mind of man to realize or in any way to imagine, more than an exceedingly small fraction of that distance. His imagination will, I think, in all such attempts, be very much limited by the greatest distance he may at some time have seen with his natural eyes.

And when the microscopist tells us of the immense number of living beings found in a drop of water, and when we must know that these diminutive creatures necessarily possess—for performing their functions of life—much of the exquisite machinery of the larger animals, how entirely incapable are we of extending our imaginations to any satisfactory apprehension of the minuteness of these things.

Thus, in whichever way we may turn our investigations, we can find no limit to the minuteness on the one hand, nor to the greatness of creation on the other.

Were we to attempt the study of a single blade of *grass*, and endeavor to learn the many combinations of the simple materials constantly surrounding us which enter into its composition; or were we to try to comprehend the power of that wonderful substance we call *heat*, its source and the cause of its undiminished supply, we should find it the study of a lifetime.

Some of the experiments we may show you this evening, may be as familiar to you as the reflection of your own face in the glass,

yet they may appear to you in a *new combination*, and possibly suggest to you some new thoughts.

You may have attended a lecture on Chemistry only last night, and have been delighted with the most beautiful and elegant discourse on the all-powerful and wonderful properties of that greatest of substances—Oxygen—and have seen with what ease the lecturer could build up and pull down all things earthly that man beholds. Or you may have followed the *Geologist* in his deep and profound researches into the very bowels of the earth, and listened with rapture as he explained the wonderful formations and transformations which these same substances have been undergoing for untold ages. Or perhaps you may have attempted to follow the *Astronomer* in his daring flights of fancy, as he endeavored to explain to you how that wonderful heat and light of the sun are kept up by the millions upon millions of meteors, which, drawn irresistibly from their paths, dash headlong into that great consuming fire.

But this evening, let us concentrate our thoughts much nearer home; let us endeavor to comprehend more fully the most interesting to us of *all* those mysterious changes; I mean that change which is produced in our own bodies twenty times every moment of our lives, by the air we breathe.

I am led to believe that we have not more fully comprehended this mysterious transformation thus going on within our own bodies, than we have truly measured *mentally* the distances to the fixed stars, or the number of days and hours since the formation of the earth, or can compass by our limited reasoning, those powerful influences which have caused the sun to send forth heat and light without measure, for unnumbered ages, and yet the source itself to be undiminished still.

I say, I am led to the belief of this general want of knowledge upon this subject, by noticing daily, and almost every hour of the day, the most intelligent and best educated men and women amongst us, so entirely ignoring the effect designed by our Creator to be produced by this constant breathing of pure and fresh oxygen and nitrogen, as to shut themselves up in *close rooms*, and breathe and re-breathe the same air, till it becomes excessively foul and poisonous.

There is no standard of taste respecting things seen. Those which we know produce the most comfort, and give us the most happiness, no matter what may be their form, we consider the most beautiful.

We cannot *see* pure air, and therefore we can scarcely call it "beautiful;" but let us hope that we may so cultivate the imagination, that if we can but comprehend, even in a slight degree, the marvellous effect that it produces on all that is human, we may soon learn to *feel* that pure air was not only among the greatest, but that it was *the* greatest of all the Creator's temporal blessings to his creature, man.

At our last lecture, I endeavored to impress upon your minds, the very large amount of air which was breathed by each individual every twenty-four hours, it being about 350 cubic feet, or 125 times our own bulk.

Now if all this great bulk was simply *nothing*, or possessed no qualities except what we could discern with our ordinary vision, it might be of little value. Our eyes are the great medium through which we receive information; but, as I said before, we cannot *see* the atmosphere, and so I fear many of us fail to appreciate the true value of pure air on this account. We are obliged, therefore, to explain its peculiarities in a secondary manner, by producing some *effect* that may be seen.

The air we breathe is composed of seventy-nine parts by bulk of nitrogen, and twenty-one parts of oxygen.

The oxygen is the *busy body;* it is the hard working, active substance that keeps up the fires, cooks the food, burns up the trash, purifies the blood and turns it from a dark purple to a bright crimson color.

[Here followed the ordinary experiments of burning sulphur and phosphorus in oxygen, those elements being consumed with great rapidity and brilliancy.] Thus you see some of the effects that may be produced with pure oxygen, which forms about one-fifth of the air, when it is separated from the nitrogen forming the other four-fifths of the ordinary atmosphere. The nitrogen seems to be a mere dilutant to keep the oxygen under control, and to prevent it from burning or destroying everything by fire or rust.

[A second experiment was here introduced, to show the indispensability of oxygen, and was explained as follows:]

Here we have an ordinary candle, which you see burns just as candles generally do; but now let us place it under this small bell glass receiver, and observe how rapidly the flame diminishes in size.

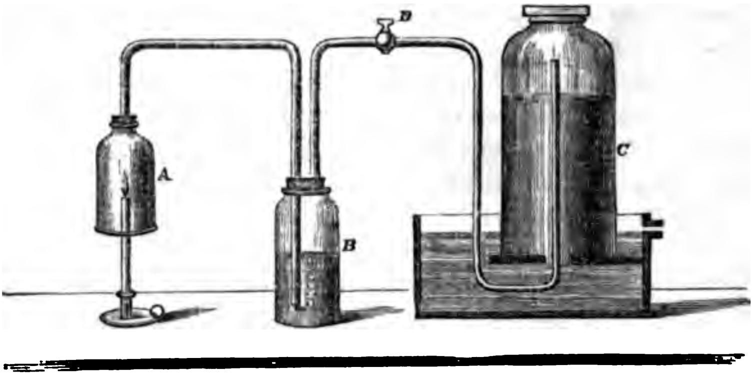
This next glass jar (B), contains lime water, or if it should chance

to be Goulard's Extract of Lead, it would answer the same purpose; and you will please notice that it is at present perfectly transparent.

From the top of this wash-bottle, we have a connecting tube passing down under and extending up again to the top of this glass jar (C), which is now filled with water.

You see the candle is now almost entirely extinguished, but please note carefully as I open the stop-cock (D), how quickly the

Fig. 4.



candle gets brighter; and you see also the air bubbling up through the lime water, and in the glass receiver the water gradually falling as the air is admitted to take its place.

The candle is now burning as brightly as though it were in the open air; it has all the oxygen it wants, but let me turn the stop-cock so as nearly to close the current of air, the velocity of which you can measure by the bubbling up of the air through the lime-water. See now how the flame of the candle has diminished! Did you ever see such a beautiful way of regulating the burning of a candle? We thus have as perfect control over it as we have over the gas-light. You will notice that the entire bottom of the bell glass is open, and don't forget that when you are burning much gas, you must have—as this experiment teaches—an outlet for the escape of foul air from the top of the room. The open fire-place, so useful for ventilation during the day, is not sufficient when the gas is lighted.

Ah! see what a change has taken place in this lime-water; it has become white and milky; Also, the water has fallen out of the glass jar, as you see, and drawn in sufficient air to take its place.

Now we are anxious to know what change has taken place in this air. The milky appearance of the lime-water is the chemist's test of carbonic acid; we will therefore assume that that has been caught there, and, as the air has thus been purified again, looks very pure as seen under the gaslight, at any rate. Let us see now if the candle will not burn just as brightly as in the open air.

Why, what can be the matter? It goes out as suddenly as if it was dropped into the water. And for what reason? It is simply because the oxygen is all burned out, and there is nothing but the nitrogen left, and that is entirely incapable of supporting combustion. By looking at this candle, you see we have scarcely burned the little cone at the top, and yet even that has produced sufficient carbonic acid to discolor this bottle of lime-water, and burn all the oxygen out of the large jar of air so thoroughly that it will no longer support the flame of a candle. An ordinary gas-burner consumes as much oxygen and forms as much carbonic acid as five persons.

Now let us see how nearly the burning of the fires in our bodies corresponds with that of the candle we have just examined.

First, let us take another bottle of lime water similar to the one we have just used, and by *inhaling* through the short tube, I draw the atmospheric air through the lime-water; but, as you perceive, although I have inhaled many times, there is no discoloration of the contents. I fear, however, if I was to continue much longer drawing the air from this (as I must confess), unventilated room, with all these gas-lights, as well as human fires burning, I would soon produce an evident discoloration; but I will reverse the preceding operation, and force my breath through the long tube, and you now see how quickly that causes the same milky appearance which resulted from the air coming from the candle.

Let us proceed now to detach this tube, and by drawing the air out of the glass receiver (c), you know that the water will flow in to take its place, even if it was thirty-two feet high. We will notice particularly the number of exhalations required to fill the jar with my breath, and likewise the number of seconds. There, you see it has taken nine exhalations, and required thirty-two seconds, and that jar, as I know, holds six quarts, or one and one-half gallons which would be represented by 346 cubic inches. This is quite excessive, as it would be at the rate of over 600 cubic inches per minute, and you remember we found only 400 the other evening as the average; it may not, therefore, show the ordinary signs of pol-

lution, but let us try it with a candle. Ah! you see it is too foul altogether to support the combustion of a candle.

I wish I could tell you something about the composition of that jar of air; but really, I know nothing about it as I ought to know, nor does any one else. The doctors tell us that one-half of all who die are killed by foul air; but I believe there is not a medical college in the whole country that pretends to teach the careful analysis of this said air. They will spend month after month discussing, and write volume upon volume to prove, that the ten-thousandth part of one drop of medicine will have more effect than a whole spoonful; but as to teaching the analysis of anything quite so common as the air we breathe, that would be too commonplace entirely; so I must simply repeat, we know nothing about it. But there have been a few Germans and Swiss, and some others, who have been able to tear themselves away from the fascinating study of medicine, long enough to make a few preliminary experiments on the more urgently important subject of the air we breathe, and to endeavor to ascertain the effect of the air upon the body, and, reciprocally, of the body upon the air.

(To be continued.)

Franklin Institute.

Proceedings of the Stated Monthly Meeting, October 21st, 1868.

THE meeting was called to order with the Vice-President, Mr. Coleman Sellers, in the Chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the Library received at their stated meeting held October, 14th inst., from the Society of Arts, London, and the Association for the Prevention of Steam Boiler Explosions, Manchester, England; l'Academie des Sciences, l'Ecole des Mines, Paris; la Société Industrielle, Mulhouse, France; der K. K. Geologischen, Reichsanstalt, Vienna, Austria; and Samuel Hart, Esq., Philadelphia.

The various Standing Committees reported their minutes.

The report of the Resident Secretary, on Novelties in Science and Arts was read, after which the meeting, on motion, adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notices.

Sloans' Architectural Review and Builders' Journal. Claxton, Remsen & Haffelfinger, Publishers, Philadelphia.

We have received the first three monthly numbers of this Journal, which we have read with interest, and can conscientiously commend in the highest degree.

The illustrations in this Journal are one of its most valuable features, and consist of ground plans, elevations, perspective views, and details of construction, all admirably executed and of great use to those for whose benefit this publication is intended. The entire work is eminently creditable to its publishers, and we wish them all success.

A Treatise on Algebra. By Elias Loomis, L.L.D., Professor of Natural Philosophy and Astronomy in Yale College. Revised edition. Harper Bros., New York. For sale by J. B. Lippincott & Co., Philadelphia.

With reference to such a work as this, by an author so widely and favorably known, it would be superfluous for us to occupy space by an extended description or criticism. We believe that we cannot do better in the interests of our readers, than quote a portion of the author's preface, in which he describes the distinctive points of the present edition of this well-known work.

"The stereotype plates of my Treatise on Algebra having become so much worn in the printing of more than 60,000 copies that it had become necessary to cast them aside, I decided to improve the opportunity to make a thorough revision of the work. I therefore solicited criticisms from several college professors who had had much experience in the use of this book, and, in reply, have received numerous suggestions. The book has been almost entirely re-written, nearly every page of it having been given to the printer in manuscript. The general plan of the original work has not been materially altered, but the changes of arrangement and of execution are numerous. In the former editions, in place of abstruse demonstrations, I sometimes employed numerical illustrations, or deducting from particular examples. In the present edition, such methods have been discarded, and I have aimed to demonstrate, with conciseness and elegance, every principle which is propounded."

A COMPARISON *of some of the Meteorological Phenomena of* OCTOBER, 1868, *with those of* OCTOBER, 1867, *and of the same month for* EIGHTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	October, 1868.	October, 1867.	October, for 18 years.
Thermometer—Highest—degree	70·00°	80·00°	90·00°
" date	11th.	19th.	4th, '58.
Warmest day—mean	63·17	70·00	78·30
" " date	11th.	19th.	6th, '61.
Lowest—degree	34·00	38·00	28·00
" date	18th & 24th.	24th & 25th.	25th, '56.
Coldest day—mean	40·33	45·33	35·80
" " date	23d.	24th.	27th, '59.
Mean daily oscillation	12·06	15·39	15·01
" " range	5·12	5·28	5·40
Means at 7 A. M.	48·92	50·71	51·18
" 2 P. M.	58·24	63·55	62·60
" 9 P. M.	52·92	55·79	55·21
" for the month	53·36	56·68	56·33
Barometer—Highest—inches	30·552	30·465	30·552
" date	30th.	24th.	30th, '68.
Greatest mean daily pressure	30·541	30·456	30·541
" " " date	30th.	24th.	30th, '68.
Lowest—inches	29·685	29·556	29·012
" date	5th.	10th.	26th, '57.
Least mean daily pressure	29·740	29·594	29·059
" " " date	5th.	11th.	26th, '57.
Mean daily range	0·190	0·175	0·148
Means at 7 A. M	30·144	30·053	29·929
" 2 P. M	30·105	30·005	29·886
" 9 P. M	30·122	30·020	29·913
" for the month	30·124	30·026	29·909
Force of Vapor—Greatest—inches	0·534	0·604	0·731
" date	3d.	5th.	7th, '61.
Least—inches	·094	·142	·065
" date	17th.	24th.	21st, '59.
Means at 7 A. M	·281	·315	·313
" 2 P. M	·304	·339	·337
" 9 P. M	·303	·350	·325
" for the month	·296	·335	·325
Relative Humidity—Greatest—per cent	91·0	100·0	100·0
" date	5th.	29th.	29th, '67.
Least—per cent.	28·0	33·0	23·0
" date	17th.	7th & 8th.	21st, '59.
Means at 7 A. M.	76·8	81·3	77·9
" 2 P. M.	59·6	55·3	56·1
" 9 P. M.	72·3	75·9	73·1
" for the month	69·6	70·8	69·0
Clouds—Number of clear days*	5·	12·	9·7
" cloudy days	26·	19·	21·3
Means of sky covered at 7 A. M	65·2	54·8 per ct	57·0 per ct
" " " 2 P. M	62·9	44·2	55·5
" " " 9 P. M	54·5	40·3	40·8
" " for the month	60·9	46·4	51·1
Rain—Amount—inches	2·240	4·020	2·951
No. of days on which rain fell	11·	7·	8·8
Prevailing Winds—Times in 1000	N22°18′W.241	N76°37′W.257	N76°38′W.233

* Sky one-third or less covered at the hours of observation.

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[redacted]